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BIOGRAPHICAL SKETCH OF BENJAMIN H. LATROBE.

Benjamin H. Latrobe was born on the 19th of December, 1806, in the city of Philadelphia. He was the fifth child and youngest son of Benjamin H. Latrobe, well known as an eminent civil engineer and architect, in the early part of the present century, and especially in connection with the Capitol of the United States, the best features of which were designed and executed by him, although he did not live to complete the building. Mr. Latrobe, senior, was descended from a French Protestant family, which had emigrated to Ireland. His father was an English clergyman, but his mother was a Pennsylvania lady of the Antes family, well known in Montgomery county of that State. He emigrated to America in 1798, and being a widower, married, in 1800, the eldest daughter of Isaac Hazlehurst, a Philadelphia merchant, and also an Englishman by birth.

The subject of the present memoir was not educated for the profession he afterwards pursued, and to which he might have been so well trained in his father's office. He was intended for the law; and, although his father died when his son was but 14, his purpose in regard to him was adhered to, and having graduated at the Roman Catholic College of St. Mary's, in Baltimore, at the age of 17, he entered a law office, as a student, and was admitted to the Baltimore bar before he had completed his twentieth year. He went soon after to New Jersey, and commenced the practice of law in Salem county; but the climate not agreeing with his health, he returned to Baltimore in 1829. Having meanwhile discovered that the legal profession was not to his taste, he left it the following year and entered the service of the Baltimore and Ohio Railroad Company, as an assistant of Jonathan Knight, then Chief Engineer of that Company.

The brother of the subject of our sketch, J. H. B. Latrobe, Esq., the distinguished legal counsellor of the Baltimore and Ohio Railroad Company, was educated as an engineer; but maturity brought to him a taste for metaphysics and law, and they have each chosen the path for which nature intended them, and are leading men in their respective professions.

Benjamin H. Latrobe, being already an accomplished draughtsman, and a fine mathematician, soon rose through several subordinate positions, to the rank of principal assistant to Mr. Knight, and in 1832, began the location of the Washington Branch Railroad, under his directions. This service occupied him until the close of 1833. In the following year, he located that portion of the Baltimore and Ohio Railroad, between the Point of Rocks and Harper's Ferry, which had not been previously established by Mr. Knight, conjointly with the Engineer of the Chesapeake and Ohio Canal Company.

In the same year he reconnoitred and reported upon a railroad route from Harper's Ferry to Chambersburg, through Hagerstown, Maryland.

In 1835, Mr. Latrobe was appointed Chief Engineer of the Baltimore and Port Deposit Railroad, which was located and built under his direction from Baltimore to Havre-de-Grace, 34 miles. The features which distinguished this road were, 3 bridges of considerable length, 2 of them with draws, over rivers of moderate depth of water, but almost unfathomable mud. They were supported upon piles, and were the first long railroad bridges of this description erected in the United States. The ferry at Havre-de-Grace was also peculiar, the cars, with freight and baggage, being transported across the river, $\frac{3}{4}$ of a mile wide, upon tracks laid upon the upper deck of a steamboat, so as to avoid breaking bulk; a plan since adopted successfully upon other railroads in this country. Mr. Latrobe left the service of the Baltimore and Ohio Railroad, when he entered the other, in 1835, but was recalled in 1836, and appointed "Engineer of Location and Construction," by that Company.

In this capacity, he executed all the surveys, planned and superintended all the works of construction, with the advice of Jonathan Knight, the Chief Engineer. He remained in the service of the Baltimore and Port Deposit Railroad Company until the opening of that work in July, 1837, and thenceforward devoted his exclusive attention to the Baltimore and Ohio Railroad surveys, which were prosecuted during that year to Wheeling and Pittsburg, on the Ohio. In 1838 Mr. Latrobe made an elaborate report upon these surveys, which extended over a section of a mountainous country upwards of 300 miles in length and 50 or 60 miles in breadth, in a manner to give much professional credit to himself. It was through this able report that Mr. Latrobe became well known to the profession throughout the country, and he gained soon after a high reputation by a report upon the principal railroads of the Eastern and Middle States, in which he was associated with Mr. Knight.

In this year, also, the four inclined planes over Parr's Ridge were replaced by a railroad, with grades of 80 ft. per mile, as located by Mr. Latrobe and constructed under his supervision, and the general direction of the Chief Engineer. Some important changes were also made in the bed of the road, by which a part of its most objectionable curves were dispensed with.

In 1839 the Baltimore and Ohio Railroad from Harper's Ferry to Cumberland, 98 miles, was finally located, and its construction, upon the plans prepared by Mr. Latrobe and approved by Mr. Knight, commenced. The work of chief interest upon that part of the road were 3 tunnels— the longest 1,200 ft.—and several bridges of considerable magnitude built of timber, upon a plan approved by Mr. Latrobe, and in which arch braces were adopted, with counterbraces and tie-rods between them. The plan of these structures is fully described in Haupt's work on bridges.

This important division of the road was open for travel in November, 1842, Mr. Latrobe having previously been appointed Chief Engineer, upon the retirement of Jonathan Knight in April of that year.

After the completion of the road to Cumberland, Mr. Latrobe was occupied during the succeeding years, up to 1847, in a variety of duties, all of which, however, related to the extension of the railroad beyond Cumberland to the Ohio river. He reconnoitred the country through Virginia, in 1843 and 1844, and in the latter year pursued his examinations into Ohio, to the leading centres of trade of that State. He also visited Richmond during each winter of these years, in aid of the efforts the Company were making to obtain an acceptable right of way through Virginia, and was deputed by President McLean, then on the eve of his departure as Minister to England, to make the annual report to the stockholders, in July, 1845, and on his recommendation they rejected the Virginia law of that year.

The transportation department of the railroad from Baltimore to Cumberland, was also under his general direction during that time, and in 1846 the old plate rail track was replaced by T rail, and many additional changes were made in the road bed, and its most objectionable curves.

In 1847 the surveys west of Cumberland were resumed, and in that and the two succeeding years, the line to Wheel-

ing, 200 miles in length, was located, and most of it placed under contract. In the location, plans, and construction of this part of the Baltimore and Ohio Railroad, Mr. Latrobe performed a most difficult task. The country presented unusually bold features, even for a mountainous region. Two main summits, one of 2,600, and one of 2,000 ft. above tide water, had to be passed, with a valley between them less than 1,400 feet above the ocean. Lines of better grade might have been had, but with shorter curves and a greater expenditure of distance and cost of construction. Mr. Latrobe selected the most direct, and easiest to build, although it involved an inclination unprecedented in leading railroad routes.

The principal summit of 2,600 ft. above tide water, between the Potomac and Youghiogheny, was passed by a grade averaging 116 ft. to the mile, for 15 continuous miles. The same grade was used for 8½ miles in descending to the valley of Cheat river; and in crossing the second summit of 2,000 ft., between this river and Tygart's Valley, about 6 miles of 105 ft. grade was used on either side.

Mr. Latrobe had adopted this location on his own responsibility, as the Company's Chief Engineer; but as it presented novel and important questions, a consulting board, composed of Jonathan Knight, Capt. John Childe, and himself, was appointed to consider the subject. Under the direction of this board, new surveys were made in 1848, which resulted, however, in showing that the best ground had already been selected; and in an elaborate report, made soon after, the location of Mr. Latrobe was approved by his colleagues, and finally adopted by the Company.

The road was accordingly constructed upon that line, and its natural features, and the works connected with them, have become well known throughout the country. Upon the 200 miles between Cumberland and Wheeling, there are 12 tunnels of various lengths,—the longest, the "Kingwood," 4,100 ft.—through a compact slate rock, overlaid in part by a good limestone roof, and for the rest of its length supported by brick arching. There is a long deep cut at each end of the tunnel. It was worked from both ends, and from 3 shafts 15 by 20 ft. sq., and 180 ft. deep. The greatest height of the ridge over the tunnel is 220 ft. The time employed on the work was about 2 years and 8 months, and the number of cubic yards removed in the tunnel, was about 90,000, together with about 110,000 yards of earth and rock outside, for the approaches.*

The next most important work was the "Doe Gully" tunnel, 1,200 ft. in length, where a bend in the Potomac river is crossed, and a distance of nearly 4 miles saved. The approaches to this work are imposing; for several miles on each side of the tunnel, the road occupies a high level on the steep hill sides, affording an extensive view of grand mountain scenery. The tunnel is through a compact slate rock, which is arched with brick to preserve it from future disintegration by atmospheric action. The fronts or façades of the arch, are of fine white sandstone, procured from the summit of the neighboring mountain. The height of the hill above the tunnel, is 110 ft. The excavations and embankments adjacent, are very heavy, through slate rock. The bridges are also numerous, and the "trestling," across the gorges, on the ascent of the Cheat River Hill, are structures of novel character, being viaducts supported by slender pillars of cast iron, very light in appearance, yet strong and durable. One of these viaducts is 46, and the other 58 ft. high; the former resting on a solid wall of masonry, whose foundation is 120 ft. below the base of the columns; the latter on a similar wall, with foundations 74 ft. below base of columns. The pillars lean inwards to give stability, and are thoroughly tied and braced, and carry 2 tracks of rails at the grade of the road.

In the design and erection of the bridges and viaducts, Mr. Latrobe was assisted by Albert Fink, a talented German engineer, who was associated with Mr. Latrobe as an assistant for several years, and is now earning a high reputation as an engineer and bridge architect, in the South-West.

The cost of the Baltimore and Ohio Railroad from Baltimore to Wheeling, 379 miles, completed June 1, 1853, was

* At the crossing of the mountain over this tunnel, previous to its completion in 1853, the grade was upwards of 500 ft. per mile, over which a locomotive engine propelled a single car at a time, weighing, with its load, 13 tons, at a speed of upwards of 10 miles per hour. When the track was wet or frosty, the engine and its load occasionally slipped backwards, and often ran with locked wheels, down to the bottom of the grade without injury.

$15,629,000, including nearly $1,000,000 for reconstruction east of Cumberland, after the road was opened to that point in November, 1842.

The working of the Baltimore and Ohio Railroad, between Cumberland and Wheeling, has abundantly manifested the judiciousness of its location and manner of construction. The high grades have been operated with great economy and entire safety, by means of a class of locomotives, using the extremely cheap mineral fuel which abounds in that region. In addition to the work already described, and upon which Mr. Latrobe has been engaged as Chief Engineer, he acted, from 1850 to '54, as Consulting Engineer of the Cincinnati, Hillsboro and Parkersburg Railroad, and in 1855, the Fredericksburgh and Gordonsville Railroad Company employed him in the same capacity.

In 1854 he visited South Carolina to examine the location of the Blue Ridge Railroad of that State, upon which he made an able report of some length, which was published by that Company. He again visited the road in 1857 to give his professional testimony upon questions connected with the object of his previous visit.

In 1851 Mr. Latrobe was appointed Chief Engineer of the North-Western and Virgina Railroad Company, extending from Grafton, a point on the Baltimore and Ohio Railroad, to Parkersburg on the Ohio river, 92 miles below Wheeling. In the contest for the right of way through Virgina for the Baltimore and Ohio Railroad, Mr. Latrobe always favored the most direct line to Cincinnati, and opposed the Wheeling terminus. He, therefore, entered *con amore* into the construction of the Parkersburg Railroad, under the charter which the citizens of that place had succeeded in obtaining.

The country between Grafton and Parkersburg was very much broken, and required patient examination to secure the best line, which was only obtained by a free resort to tunnelling through the numerous high and sharp ridges dividing the many watercourses. No less than 23 *tunnels*, in 104 miles, had to be driven, the longest 2,700 ft. These tunnels are the most striking features of the road. There are many bridges, but none of great magnitude, and several embankments, but none of extraordinary altitude or length. The depot arrangements upon the Ohio river at Parkersburg are worthy of attention, for their excellent facilities for handling freight by means of machinery used for raising and lowering it from steamboats.

In 1856, Mr. Latrobe was appointed President of the Pittsburg and Connellsville Railroad Company, and also of the Northern Virginia Railroad Company. From this last position he retired in the latter part of 1857, and devoted his whole attention to the direction of the Pittsburg and Connellsville Railroad, performing, from early in 1858, the duties of Chief Engineer of the same Company. In 1864 he retired from the Presidency of this Company, retaining, however, the Chief Engineership, which he still holds.

In 1863 he became Consulting Engineer of the Philadelphia, Wilmington and Baltimore Railroad Company, in connection with the bridge then about to be built across the Susquehanna river at Havre-de-Grace. In 1865, he was appointed Consulting Engineer of the Missouri Railroad Company, more especially in reference to the bridge about being erected over the Missouri river at St. Charles, which position he held for about two years.

In 1866 he was appointed Consulting Engineer to the Governor and Council of Massachusetts, in connection with the Troy and Greenfield Railroad, and Hoosac Tunnel, and held the office until January, 1869, when he resigned.

Early in 1869, on the invitation of the late John A. Roebling, he became one of a Consulting Board of Engineers upon the plans of the "East River Suspension Bridge," and continued to act with the Board until its services were terminated, and report made in the autumn of the same year.

Such is a brief summary of 40 years of the professional life of this distinguished Civil Engineer. In looking through the numerous reports from his able pen, the author is at a loss to select from among them such as might be considered most worthy of notice and deserving of preservation as part of the professional history of his time.

In 1846, when the Baltimore and Ohio Railroad Company was hesitating whether

it would extend its road west of Cumberland to Pittsburg through Pennsylvania, or to some Point below on the Ohio, in Virginia, the Pittsburg and Connellsville Railroad Company, having located a part of its road, offered its charter to the Baltimore and Ohio Railroad Company (to whom Pennsylvania had refused to renew its former right of way on terms that would be accepted).

The Company decided, however, to go through Virginia rather than through Pennsylvania, even if they were compelled to make their terminus on the Ohio as far down as Wheeling. This decision was an unfortunate one for the Company; for if the road had been first made to Pittsburg, the State of Virginia would have finally accorded the right to Parkersburg (as has since been proved), and the 100 miles to Wheeling would have been saved, and could well have been spared, for in the final arrangement it has become mainly a local road.

Mr. Latrobe is now engaged in endeavoring to accomplish that which he desired to have seen effected at first, and should he be so favored, may live to fill up the measure of his professional ambition—the completion, under his direction, of two great lines of railroad which are equally necessary to Baltimore.

He has been invited to take charge of other lines of railroad, but the interest he has always felt in the city of Baltimore, and the completion of her connections with the West, has always led him to decline engagements incompatible with that paramount object of his career as a Civil Engineer.

Mr. Latrobe is as distinguished for his modesty, urbanity, and gentlemanly deportment, as for his eminence as an engineer. When complimented on the opening of the Baltimore and Ohio Railroad, at the Fairmount banquet, he characteristically replied, in part as follows:

"The merit which has caused my name to be mentioned in this connection, would doubtless have been exhibited to the same extent by any other professional man, who had the same opportunity of constructing a similar road over such a country. The general maps indicated the courses of the streams that were to facilitate the work; but where the mountains were to be crossed and tunnelled, and the rivers to be spanned, was a matter of careful examination, in which I was aided by the talent and perseverance of skilful assistants, whose valuable services I shall always take pleasure in acknowledging."

In another place he says: "In crossing or tunnelling the mountains, and spanning the rivers, sometimes one plan had to be adopted and sometimes another, and I have been constantly surrounded by able and accomplished assistants, to whom I take pleasure in according their share of whatever merit there may be found in the task I have accomplished."

A less sanguine temperament than that possessed by Mr. Latrobe would have recoiled from the task he saw before him, but its very difficulties seemed to give the work new attractions.

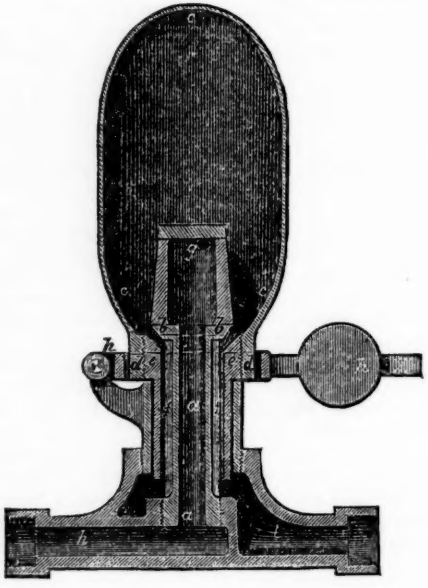
These works, from the Chesapeake to the Ohio, are a noble monument to his professional skill and indomitable perseverance.

CHATWOOD AND CROMPTON'S STEAM TRAP.

From "Engineering."

We subjoin an engraving of a form of self-acting escape valve for drawing off water from steam pipes, etc., which has been designed and patented by Mr. Samuel Chatwood and Mr. James Crompton, of Bolton. The apparatus consists of a short vertical pipe open at the top, which should be at a lower level than the cylinder or other steam vessel to be drained. Around the upper part of the pipe is formed a valve face, the face being downwards. The upper part of the pipe with the valve face above-mentioned is enclosed within a small vessel closed at the top, and having at its lower end a neck, which fits on a parallel part of the pipe below the valve face, and carries a corresponding valve seating set with its face upwards, so that when the vessel is lifted up the valve and seating are in close and steam-tight contact; and when the vessel drops, the seatings separate and allow any fluid contained in the vessel to escape through grooves or openings left in the neck.

The action of this apparatus is as follows: When steam only is in the pipes the vessel is pressed upwards owing to the internal area of the vessel being greater at the top than at the bottom by the amount of the area of the valve face, and thereby the valve and face are closed together so as to prevent the escape of steam. When water is formed in the pipe by the condensation of the steam, it gradually accumulates in the closed vessel, until by its weight it overcomes the upward pressure of the steam, and causes the vessel to drop, thereby opening the valve and allowing the water to flow out through the openings in the neck until the weight of the vessel and its contents falls below the upward pressure of the steam, which then lifts the vessel upwards again, thereby closing the valve and preventing the escape of any steam. There is placed above the mouth of the vertical pipe above-mentioned a guard, against which, when the valve opens, the condensed fluids are driven by the pressure in the steam vessel, so that by their downward reaction they tend to keep the vessel down and the valve open until the



vessel is empty or nearly so. The designers also apply a weighted lever to the closed vessel, by which the valve may be weighted more or less by moving the weight along the lever so as to regulate it to suit the pressure of steam in the engine or other steam vessel to which the apparatus is applied. The same end may also be effected by applying weights directly to the valve without the intervention of a lever, or spring might be employed in place of a weight.

The annexed figure shows one arrangement of the apparatus above described. In this figure, a is the short vertical pipe having the valve face, b, at its upper part; c is the vessel closed at the top, and having at its lower part the neck, d, which carries the valve seating, e, corresponding to the valve face, b; f, f, are the grooves through which the condensed liquid is to escape; g is the guard carried above the upper end of the vertical pipe, a. The steam enters at k, and the condensed liquid is conducted off through the outlet l. The shape of the casting forming the lower part of the apparatus may be considerably varied. The weighted lever shown at Fig. 1 for drawing downwards the vessel, c, is marked h.

AN ELEMENTARY AERONAUTIC APPARATUS.

Translated from "Les Mondes."

M. Foselli, during the progress of the siege, has being very seriously studying the problem of navigable aeronautic apparatus. We shall not presume to say that he has solved the problem, but his attempt certainly presents some new and ingenious peculiarities. His *aerostat* is a simple cylinder terminated by a cone intended to cleave the air, and surmounted by cones called *compensateurs*, which, by means of a very simple apparatus, may be made salient or re-entrant, so as to equilibrate all the variations in pressure of the gas; so that it is not necessary to throw out ballast, or to let off gas, in order to rise or descend. The cylinder is firmly fixed to a metallic chamber or cylinder with inflexible walls, of the same length as the machine. The chamber carries at its extremities propellers or helices which are intended to drive and guide the vessel. It is divided into compartments, each having its special use. One is hermetically sealed and is to hold atmosphere to be breathed when at a very great height. M. Foselli does not think it possible to steer in the disturbed atmosphere of the region of snows; but intends to reach that great elevation in which there is absolute calm. He estimates that in the region of perpetual calms atmospheric tension is reduced to one-half of what it is at the surface of the earth. Hence it was necessary to assure himself by rigorous calculations that it would be possible at so great an elevation to introduce sufficient air into the living chamber to maintain an atmospheric pressure of 750 millim., which is necessary for the normal action of the essential organs of life. M. Foselli was much surprised at finding that the arm of a single man acting upon a small air-pump will maintain, at ordinary tension, an amount of air sufficient for the respiration of several hundred persons.

In a very rarefied and calm atmosphere a very slight motive force, or a very small screw, is sufficient to make the machine move, even when loaded. The experiments leave nothing to desire; the results are decisive.

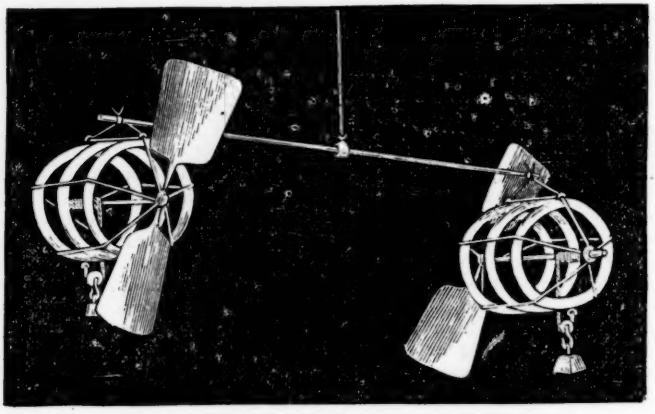
A difficult problem remains for solution; that of the *orientation* of the machine. M. Foselli attempted only to discover some practical way of determining the point above which the aeronaut is floating. He succeeded in his attempt on the 26th of December; and on that day he communicated his method to M. Dumas, Secretary of the Academy of Sciences, and to myself; but it was at that time absolutely necessary that it should remain a secret.

The method consists in drawing diagonals corresponding to the 4 cardinal points upon the 4 faces of a sufficient number of towers or upon the roofs of churches, with large conspicuous letters, so that they may not escape the notice of the aeronaut provided with a field glass. Besides this, should be printed the name of the place.

By this means the aeronaut will know his place and the direction in which he is going; again, knowing the time and distance between two places, he can approximately determine the velocity of his balloon. This method is ingenious and the only one sure to indicate to him his course through the sky. In presenting his project and plan to the Academy of Sciences, M. Foselli had but one end in view; that of paying to France, the country of his adoption, the debt of gratitude for the immense service rendered his native land, Venetia, in delivering it from a foreign yoke. "I would buy," said he, "with my blood, the honor and good fortune to aid in the deliverance of Paris and France. Let my efforts be taken as tokens of my devotion."

He had constructed a model of his machine of sufficient scale to resolve a great number of problems relative to progression in the air; and he is certain that in a very calm atmosphere, a motive force relatively feeble, like that of the hand of a man acting upon a screw of small diameter, could move a load of several hundred kilograms supported by the aerostat. Besides, he has discovered an unexpected fact which may lead to the means of navigating against the wind, or force the wind itself to give the machine a motion different from its own. He had suspended his model and had fixed to it two screws of like form and dimension, but mounted so as to act in opposite directions. These were set in motion by the descent of a weight. Who would not have supposed

that under the action of these two screws, opposite in direction, equal and of contrary signs, the apparatus would have remained at rest? Yet it moved with a velocity greater than that due to the action of a single screw. These curious



results suggested to M. Foselli the happy thought of converting his model into an instrument (of which a figure is given above) by means of which one can illustrate a great number of phenomena relative to the motion of bodies in fluids and gases.

SOLAR HEAT—ITS INFLUENCE ON THE EARTH'S ROTARY VELOCITY.

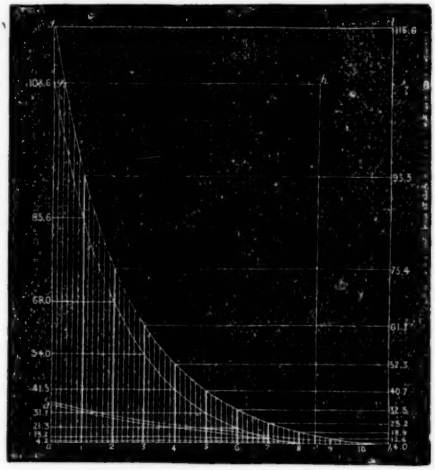
By CAPTAIN JOHN ERICSSON.

(*Continued from page 565.*)

Illustrations and descriptions have been prepared explanatory of important modifications of the dynamic register described in the preceding article adopted in order to control the irregular resistance of the atmospheric air against the rotating sphere, unavoidable in employing gas-flames for heating the equatorial belt; ut the subject having already occupied ore space than intended, I now propose state only the result of the experiments hich have been made with the modified instrument, the dimensions of which, it should be observed, have been considerably increased; the motive power, however, remaining unchanged. It is scarcely necessary to remark, that a complete demonstration and record of an investigation of this complicated nature would present an array of figures inadmissible in these columns. The accompanying diagram has, therefore, been devised to dispense with figures; the relations of time, velocity, and resistance, being presented in such a manner that, among other facts, the amount of mechanical energy which disappears during the experiment, may be ascertained by mere inspection. For the purpose of saving space and facilitating direct comparison, this diagram has moreover been so arranged that the record of the experiments in which heat and refrigeration have been employed, is placed on the same base line with the record of the experiments in which difference of temperature was prevented. The divisions on the base line, *a b*, mark the time of rotation, the large spaces indicating minutes and the smaller divisions 10 sec. each. The length of the ordinates of the curve, *c b*, resting on the base line, represents the number of turns performed in a given time when the rotating sphere is not subjected to the action of heat and refrigeration; while the length of the ordinates of the curve, *d e*, represents the

number of turns when heat and cold are being applied. It will be readily perceived that, for instance, the ordinate between *l* and the curve, *c b*, represents the number of turns per minute at the commencement of the second minute, while the ordinate 2 represents the number of turns per minute at the commencement of the third minute, and so on for all the other ordinates.

The *permanent* friction of the instrument, *i. e.*, the friction of the pivot on which the sphere turns, being practically inappreciable, it will be evident that the resistance opposing the rotation will vary in the ratio of the square of the velocities. Hence, as the respective ordinates between the curves, *c b*, and *d e*, and the base line, represent the *velocities*, it will only be necessary to square these ordi-



nates in order to determine the exact amount of resistance to the periods indicated by the divisions on the base. Accordingly, the ordinates mentioned have been prolonged in the ratio of their squares, the curves, *f b* and *g e*, being the result of this prolongation. Obviously, the lengths of the ordinates of these curves resting on the line, *a b*, represent accurately the amount of resistance opposed to the rotation of the sphere at the times indicated by their intersection with that line. The rate of velocity, *i. e.*, the number of turns per minute, performed by the sphere at the commencement and at the termination of each minute, will be found by referring to the figures marked on the vertical lines, *f a* and *l b*. Thus, for instance the rate of velocity at the termination of the seco d minute is 75.4 turns, when refrigeration is *not* applied; while the rate is 68.0 when the cooling medium is applied at the pole. As might be expected from the irregular nature of the external resistance opposed to the rotating mass, the curves, *f b* and *g e*, do not correspond with any of the conic sections. The available motive power of 2,540 foot-grains *expended* during the experiment, is represented by the superficies, *f a b*; the energy *developed* being represented by the superficies, *g a e*. Assuming the former to be 1.000 the latter as shown by our diagram will be 0.763, difference=0.237; hence the amount of lost energy is 0.237 $\times$2540=601.98 foot-grains. Now if the weight of water which is condensed at the pole and returned to the equator, multiplied by the height necessary to generate the rotary velocity acquired during the transit, should amount to 601.98 foot-grains, the fact will be established that the current of vapor has not, during its passage from the equator to the pole, restored any of the energy abstracted from the sphere by the current of water flowing in the contrary direction. The quantity of water condensed and returned to the equatorial belt being readily ascertained by observing the increment of temperature of the con-

tents of the polar cistern, it is easy to show that the energy abstracted from the rotating mass by the water thus transferred from the pole to the equator, corresponds so nearly with the differential mechanical energy represented by the superficies, *f g e b*, that the compensation resulting from the tangential force exerted by the particles of the currents of vapor against the surface of the sphere of the dynamic register, is practically inappreciable; precisely as we find that the compensating tangential force of the currents of vapor which sweep over the basin of the Mississippi from west to east (neutralized by the currents which pass from east to west) is an inappreciable fraction of the retarding energy of 19,336,000,000 foot-pounds per second, exerted by the *water* which the Mississippi carries in the direction of the equator.

Having thus analyzed the opposing energies called forth by the waters flowing towards the equator, and of the returning vapors, the condensation of which replenishes the river basins, we may now enter on a computation of the aggregate amount of the retarding energy, and the consequent diminution of the rotary velocity of the earth, caused by the rivers enumerated in the Table accompanying a previous article. The total of the retarding force entered in the last column of that Table, it will be found, amounts to 53,857,788,300 foot-pounds, per sec., which sum multiplied by 86,400 sec., shows that the earth has to overcome a resistance of $4{,}653{,}313 \times 10^6$ foot-pounds during each revolution. Multiplying this resistance by 36,524 days, we ascertain that the retarding energy of the water transferred in the direction of the equator by the entire Southern river systems of both hemispheres, amounts to $16{,}995{,}760{,}069 \times 10^{10}$ foot-pounds in a century. Now, in order to determine the diminution of rotary velocity consequent on this counteracting energy, it will be indispensable to compute the earth's rotary vis viva. The elements necessary in this computation are, volume, time of revolution, specific gravity, and the position of the centre of gyration of the rotating mass. The two first-named elements are known with desirable accuracy; the third element, specific gravity, has been ascertained with tolerable accuracy; but the position of the centre of gyration, which depends on the internal temperature of the globe and the disposition of its constituent parts, has not yet been determined. Physicists assume that the density of the globe increases towards the centre in arithmetical progression; but this assumption is not sustained by sound reasoning. Our space not admitting of discussing this complicated question at length, let us merely consider the leading fact, that, at a distance of only $\frac{1}{200}$ of the earth's radius=1,044,400 ft. from the surface, the weight of a superincumbent mass of fused granite, will exceed 900,000 lbs. to the sq. in.=60,000 atmospheres. Under this pressure the weight of air will be 70 times that of water, and 3.5 times that of the heaviest metals. Gold, at the point of fusion, is 7 times heavier than fused granite, while neither of these solids loses more than $\frac{3}{100}$ of specific gravity at melting heat; a fact which proves conclusively that high temperature of metals and minerals is not incompatible with great density. Hence, fused granite, in the earth's interior, may be many times heavier than the cold mineral at the surface. Unless, therefore, we are prepared to dispute the assumption that fused granite under a pressure of 900,000 lbs. to the sq. in. will have its specific gravity doubled—involving a density less than one-third of fused gold not subjected to compression—we must admit that the specific gravity of the earth at the depth of $\frac{1}{200}$ of the radius, is so great that, if the density, as physicists have assumed, increases in arithmetical progression towards the centre, our planet would be many times heavier than it is. We are compelled, therefore, to reject the accepted theory; more especially as the stated enormous pressure consequent on superincumbent weight, takes place at only $\frac{1}{200}$ of the earth's radius below the surface.

In accordance with the foregoing reasoning, our computation of the earth's rotary vis viva will be based on the assumption that the mass is *homogeneous*. It is true that the specific gravity at the surface is somewhat less than one-half that of the entire mass; but we have shown that at a depth of $\frac{1}{200}$ of the radius from the surface, the density is so great that if it continued to augment in arithmetical progression, the specific gravity of the globe would far exceed that which has been determined by careful investigation.

Nor should we lose sight of the important fact, that the temperature corresponding with the compression produced by the superincumbent weight, is so great that the component parts of the central mass may be as light as pumice, notwithstanding the enormous external pressure. Consequently, it may be satisfactorily demonstrated that the earth's circle of gyration extends considerably *beyond*, in place of being within that of a *homogeneous* sphere, agreeably to the accepted theory of augmented density towards the centre. In our computations, however, we will assume that the circle of gyration is that corresponding with homogeneity, which, in accordance with the property of spheres, is 0.6326 of the great circle. Sir John Herschel's determination shows that the mean diameter of the earth considered as a perfect sphere is 7912.41 statute miles, or 41,777,524 ft.; hence if we assume the specific gravity to be 5.5 we can readily calculate that the weight is $1,308,608 \times 10^{19}$ lbs. Multiplying the equatorial velocity, 1519.07 ft. per second, by 0.6325, we ascertain that the mean rotary velocity of the entire mass of the earth is 960.81 ft. per second; a rate acquired by a fall of 14,424 ft. The earth's rotary vis viva will accordingly amount to $14,424 \times 1,308,608 \times 10^{19} = 18,875,361 \times 10^{22}$ foot-pounds. The mind being utterly incapable of conceiving this stupendous energy without comparison with mechanical energies of less magnitude, let us ascertain to what extent it will be diminished by the retardation exhibited in the Tables previously presented, namely, $16,995,760,069 \times 10^{10}$ foot-pounds, exerted in the course of a century by the southern river systems of both hemispheres. Dividing the stated retarding energy in the earth's vis viva, thus: $\frac{18,875,361 \times 10^{22}}{16,995,760,069 \times 10^{10}}$ we find that notwithstanding the enormous amount of retardation exerted in a century only $\frac{1}{111,060,000}$ of the rotary energy of the earth will be destroyed in that time. And if we multiply the fraction thus presented, by 10,000, we learn that at the end of 1,000,000 years, the rotary energy of the earth will be only $\frac{1}{11,106}$ less than at present! By no other comparison, probably, than the one we have instituted, could we clearly comprehend the magnitude of 18,875, 361×10^{22} foot-pounds of mechanical energy.

Let us now calculate the effect of the tabulated resistance, on the earth's rotary velocity, with reference to *time*. The retardation observed by astronomers being as before stated, about 12 sec. in a century, our object will be to ascertain how far this retardation may be attributed to the counteracting energy under consideration. Multiplying, then, the number of seconds in a century, 3,155,673,600 by the retarding energy of 53,857,780,300 foot-pounds per second, entered in the Table, we establish the fact before adverted to, that the total retardation is $16,995,760,069 \times 10^{10}$ foot-pounds in one century. Dividing this retardation in the vis viva, it will be seen that the earth loses $\frac{1}{111,060,343}$ of its rotary energy in the course of 100 years; but in calculating the *time* corresponding with this loss, we have to consider that the velocities are as the square root of the forces, and that, consequently, the rotary velocity will not be reduced as rapidly as the rotary energy. Evidently, if the diminution of energy and velocity corresponded exactly, the retardation of the earth's rotary motion during one century would be $\frac{3,155,673,600}{1,110,592,343} = 2.8414$ sec. But in accordance with the laws of motion referred to, the diminution of velocity during the century, will be in the ratio of the square roots of the earth's vis viva at the beginning and at the termination of that period. Now this ratio being readily computed, as we know the amount of energy lost in one century while the time in seconds is also known, we are enabled to show by an easy calculation that the earth suffers a retardation of 1.42071 sec. Adding the retardation occasioned by the tabulated sedimentary matter=0.00105 sec. ascertained in the manner explained, the total retardation of the earth's rotary velocity in a century, at the *present* epoch, will be 1.42176 sec. The vastness of the rotary vis viva of the earth having already been discussed, it will not be necessary to offer any explanations with reference to the insignificance of the stated retardation, in comparison with the magnitude of the counteracting energy exerted by the water and sediment of the entire river system presented in our Tables.

We have now to consider the influence on the earth's rotary energy exercised by rivers, the course of which is in the direc-

tion of the poles. Evidently river water running *from* the equator, will have its motion round the axis of rotation, continually diminished as it reaches the northern parallels; hence rotary energy will be imparted to the earth by all rivers flowing towards the poles. At first sight, it will be imagined that the energy thus imparted will neutralize the retarding force exerted by the waters transferred towards the equator. Certain physical causes, however, prevent the imparted energy from restoring any of the earth's lost vis viva. The subject will be most readily comprehended by an examination of the nature of the neutralizing force exerted by the following great rivers, namely, the Lena, Yenesei, Obi, and Mackenzie, which furnish the principal amount of water discharged into the Arctic Ocean. These rivers drain an area of 3,840,000 sq. miles, the latitude of the centre of their basins, and their outlets, being very nearly in the same parallel. The mean of the former is 59 deg. 30 min., that of the latter 69 deg. 56 min. Accordingly the mean circumferential velocity of outlet is 421.18 ft. per second, while that of the centre of basin is 770.95 ft. per second. It will be seen, therefore, that a diminution of rotary velocity of 770.95 — 521.18=249.77, say 250 ft. per second, takes place during the transfer of the water from the centre of the basins of these rivers to their outlets. Now a velocity of 250 ft. per second is produced by a fall of 976.5 ft., hence each *pound* of water discharged into the Arctic Ocean by the before-named rivers, will impart a mechanical energy of 976.5 foot-pounds. Apart from this powerful neutralizing force of a given weight, the quantity of water transferred is so great owing to the vast extent of the basins, that, notwithstanding the moderate precipitation in high latitudes, the rotary energy imparted to the earth will balance the retardation of the 136 rivers entered in our tables. It scarcely requires explanation that the stated enormous force exerted by the water transferred by the great northern rivers, is owing to the rapid diminution of rotary velocity in approaching the pole; a single degree of latitude at the point where, for instance, the river Lena discharges into the Arctic sea, having a greater fall than *ten* degrees have within the tropics. It would be waste of time, however, to compute the exact amount of energy imparted to the earth by the Arctic rivers, as will be seen by the following examination of the subject. Unquestionably, if the supposed pound of water on entering the Arctic Ocean at once evaporates and ascends into the atmosphere, we must admit that an impulse of 976.5 foot-pounds has been imparted to the earth by its transfer from the centre of the river basin; but, if it should be found that in place of evaporating on entering the cold polar sea, the pound of water commences a retrograde motion towards the equator through Behring's Straits or through the wide channel between Norway and Greenland; and if we should find also that when it crosses the 59 deg. 30 min. parallel (the same as that of the centre of the river basin) it has not yet been converted into vapor, we must then admit that the whole of the energy imparted to the earth by the *approach* towards the axis of rotation, during the original transfer to the polar sea, has been completely neutralized by the retardation consequent on the *retreat* from the axis of rotation, during the southerly course to the last-mentioned latitude. Following our pound of water during the continuation of the motion towards the equator, we may discover that it has not changed its form into vapor even when reaching latitude 47 deg. 45 min., at which point the circumferential velocity is exactly 250 ft. per second greater than that of the centre of the basin from whence the motion proceeded. In that case, not only has the imparted energy been neutralized, but a *retardation* of 976.5 foot-pounds has been called forth by the pound of water, the course of which may possibly continue until it mixes with the warm water within the tropics. Let us guard against confounding the movement of the water discharged into the Arctic sea by the northern rivers, with the currents produced by the combined influence of lunar attraction, winds, differential oceanic temperature, and solar attraction. It has long been recognized that the water poured into the Arctic sea by the great Asiatic rivers, is the result of condensation of vapors raised by the sun within, or near, the tropics. A corresponding amount of water must, therefore, be returned from the polar sea, or its surface would be elevated, and that of the tropic-

al seas suffer a proportionate depression. The reader cannot fail to perceive the important bearing of these facts on the question of retardation of the earth's rotary velocity.

The result of the experiments with the dynamic register proves that the rotary motion possessed by the vapors on leaving the equatorial seas, may be almost entirely destroyed by being converted into heat during their course towards the basins of the northern rivers; hence imparting no perceptible tangential force to the earth. Accordingly, the return to the tropical seas of the water which is continually being discharged by the northern rivers into the polar seas, will, on account of the increased velocity round the axis of rotation imparted during the southern course, subject the earth to an amount of retardation far exceeding that produced by rivers flowing towards the equator. It may be asked under these circumstances, why the latter rivers have been tabulated, and their inferior retarding energy calculated. The rivers flowing in the direction of the poles have been examined, tabulated, and their counteracting energy calculated; but the question of attendant retardation of rotary velocity cannot properly be entertained until certain other counteracting influences shall have been examined. The publication of the Table containing the southern rivers has been deemed necessary as a *point d'appui* facilitating demonstrations intended to establish the fact that, independently of the counteracting force of the tidal wave (hitherto greatly overestimated), the retarding energy called forth by the evaporation within the tropics, and the consequent condensation and precipitation in the temperate zones, fully account for the retardation of the earth's rotary velocity—12 seconds in a century—inferred from the apparent acceleration of the moon's mean motion.

P. S.—Referring to the solar pyrometer, some misapprehension appears to exist concerning the indication of the focal thermometer. It is asserted that the loss of heat and consequent reduction of the temperature indicated by the focal thermometer, cannot, as assumed in our demonstrations, lead to an overestimation of solar intensity. A moment's reflection, however, will show that, agreeable to the adopted mode of computing solar intensity, *increase* of the temperature which is imparted to the focal thermometer by a radiator of given intensity will cause corresponding reduction of the deduced solar intensity. It was demonstrated in the article relating to the concave spherical radiator, that the sun, notwithstanding its size, is not capable, owing to the vast distance, of transmitting to the earth more than $\frac{1}{3619}$ of the temperature which the incandescent radiator transmits to its focus, equal intensity of radiant heat being assumed. Hence, it was inferred that the temperature of the sun must be 3,619 times higher than that of the radiator in order to transmit to the boundary of the earth's atmosphere as high a temperature as that transmitted by the radiator to the focal thermometer, viz., 117.2 deg. But the temperature produced by the sun's radiant heat at the said boundary being only 84.84 deg., it was shown that the radiant power need not be more than $\frac{3619 \times 84.84}{117.2} = 2619.76$ times greater than that of the incandescent radiator, in order to produce a temperature of 84.84 at the atmospheric boundary. The temperature of the radiator during the trial of February 4, 1871, was 1699.39°; consequently $2619.76 \times 1699.37° = 4{,}451{,}941°$ is the solar intensity deduced from a differential focal temperature of 117.2 deg. Fahr. The *actual* temperature, however, transmitted to the thermometer placed in the focus of the incandescent radiator, during the trial referred to, was, it will be seen by reference to the Table, 157.83 deg. Now, comparisons with experiments conducted in vacuo, have shown that when the heat transmitted by radiation reaches 160 deg., in an atmosphere of 40 deg., the loss occasioned by exposing the thermometer to the surrounding air will be fully 0.06 or 11 deg. This great reduction of temperature is caused by the feeble energy of radiant heat compared with the powerful refrigeration produced by currents of air. We have accordingly to substitute $117.2° + 11° = 128.2°$, for 117.2° focal differential temperature. Agreeable to the assertion the correctness of which we are going to disprove, the increase of focal temperature ought to show an *increase* of solar intensity. That the converse will result from increased focal heat will be indisputably established by simply repeating

the foregoing calculation, substituting the focal temperature 128.2 for that of 117.2°. Thus $\frac{3619 \times 84.84}{128.2°} = 2394.97$ times greater temperature of the sun than that of the radiator—1699.37° Fahr.—will be required to cause an elevation of temperature of 84.84 on the Fahrenheit scale, at the boundary of the atmosphere. Basing our computation on the stated *high* focal temperature, we accordingly *reduce* the sun's temperature from 4,451,941°, to $1699.37° \times 2394.97 = 4{,}069{,}940°$. The fallacy of the assertion that diminution of focal heat cannot lead to an over-estimation of solar intensity, has thus been fully proved. At the same time we have shown that when due allowance is made for loss of focal heat, the solar temperature deduced from the indication of the incandescent radiator, corresponds very nearly with the temperature deduced from the indications of the solar pyrometer, viz., 4,063,984° Fahr.

ASTRONOMICAL OBSERVATION.

From "Nature."

The statistics of modern astronomical observation would, we suspect, be very curious, if it were possible to get at them. A report showing the gradual increase in the number of telescopes manufactured during the last fifty years would be very interesting; and so would be a table comprising at once the advance in their dimensions and the diminution in their cost. The result would, we believe, be such as at first sight to cause great surprise among those unacquainted with the subject, or those whose recollection does not go back to days when five inches was as extraordinary an aperture for an object-glass, as double that size is now. But the value of these, as of other tabular statistics, would suffer material abatement, if they were applied to establish any other conclusions than those to which they directly lead. For instance they would probably be fallacious, if considered as inferring a proportionate increase in the number of important observations. In order to bring out such a result, we require, so to speak, another factor, and a very essential one—a corresponding increase in the number of competent observers. This, we fear, may not have been commensurate with the advance of optical means; at least, except upon the supposition of some such deficiency, it is difficult to understand what becomes of the multitude of really good object-glasses which are annually produced, not only in England, but in Germany and America. A large proportion of these, we are led to think, must be purchased to be looked at, and not looked through, or handled as mere toys for the amusement of people who do not know what to do with themselves in an idle evening. This was not so much the case in the early days of telescope manufacture. The greatest master of figuring specula in his own time was also the greatest proficient in using them; it is needless to add the name of Sir William Herschel. And so the fine reflectors in Germany were placed at the same period in the hands of the leader of all accurate selenographical investigations, J. H. Schröter. These were "the right men in the right place." Even then, it may be said, many noble reflectors went, no one knows where, the greater part of them long before this time useless from tarnish, or, still more mortifying to think upon, ruined by unskilful repolishing. Still, admitting this, the disappearance of powerful instruments does not seem to have been so remarkable in those days as it is now, and the quantity of really valuable observations appears to have been greater in the end of the last and the early part of the present century, in proportion to the means of observing.

This is not a very encouraging view of the present state of this branch of astronomy. But, if well founded, as we believe it to be, we might expect that there would be some assignable reasons for it; and, in fact, several are sufficiently obvious. One certainly is, that the process of discovery is not, generally speaking, renewable. What has been once detected is usually placed on record, in bar of all future claims. So it has been in the science of music; a man might arise among us with the fervid genius of Handel, but he could not write the Halle-

lujah Chorus over again; and doubtless the spirit of Mendelssohn must have been cramped by the impossibility of employing many of the noblest and most impressive subjects which had been anticipated by his predecessors. And so it has been in the researches of geography. The enterprising explorer has now to go much farther in pursuit of "fresh woods and pastures new," and every Alpine season is so rapidly narrowing the number of summits untrodden by the foot of man, that the excitement of a first ascent will soon have to be sought in remoter regions. Thus in astronomy, though it cannot be said that there are no worlds left to conquer, yet all the larger and more conspicuous features of the heavenly bodies have been long ago so fully noted and recorded, that what remains for exploration is chiefly of that delicate character which, without being the less interesting from its minuteness, is less accessible, for that reason, to the possessors of ordinary instruments. And on this account many a student who might well have risen from the ranks in the earlier days of scientific campaigning, is now compelled to remain in comparative obscurity—a mere spectator, when he might well have taken his place among the discoverers of fifty years ago.

Another reason why tools have multiplied without a corresponding increase of good work, may be this, that looking upon the observer and his instrument as a complex apparatus, the improvement of the intelligent has not kept pace with that of the material part. In fact, it is impossible that it should. The eye is but what it was when David learned humility from considering God's heavens, the work of His fingers, the moon and the stars, which He hath ordained; the intellect, though more developed and cultivated, is not more strong and piercing than it was in the days of Hipparchus; man does much more with his brain, but he has no more brain to do it with, than his uncivilized ancestors; and observers may, and will, be collectively multiplied without being individually improved. Every man that has eyes does not know how to use them; or, not failing in this respect, he may lack other requisites: he may not know what to look for, or where to find it; or he may be deficient in his handling of the faithful pencil or the expressive pen. And so it comes to pass that the capacities of instruments may be much in advance of the abilities of those who use them.

Besides all this, there is a physical obstacle of an entirely different character, which must not be forgotten,—the unimprovable constitution of our own atmosphere. This will ever be a sore subject for the zealous observer, especially among ourselves. If even Secchi finds fault with the glorious Roman heavens, what have we not to regret in our own murky, and fuzzy, and restless skies? Who that has read the most graphic as well as instructive writings of Sir J. Herschel is likely to forget his complaints of "twitching, twirling, wrinkling, and horrible moulding?" and who that has had much actual experience of observatory work will not endorse all this with a very lively fellow-feeling? The nights may easily be numbered, during a long season, in which the defects of the atmosphere do not overlie those of the instrument, and when the observer has not rather to wish that he could see all that his telescope could show him, than to long for greater power or light, to be expended in making atmospheric disturbances yet more conspicuous and prejudicial. The only way to obviate this grievous hindrance is to get above it; and no man has yet done this except Professor Piazzi Smyth in his most successful "Experiment;" it was said, indeed, that the French observers were about to follow his example and to plant their instruments on the Pic du Midi de Bigorre; but we have never heard whether the idea has been carried into execution. And, however striking may be the advantage of such a plan, it must ever be confined to a favored few.

We have dwelt at some length on a view of the present state of astronomical observation, which, though rather unfavorable, we believe to be substantially true. But it is not to be inferred that this is its sole aspect. There are, as usual, two sides to the shield; and much is to be said that is of an opposite tendency. If, for instance, we have asserted that for some time past observers have not multiplied in proportion to the means of observation, this is but a relative statement; the absolute fact is that at no former period has there been so numerous, or so zealous, or on the whole so competent a band of astronomical students. And of

this we have a very pleasing evidence in the recent formation of an astronomical society expressly devoted to physical observation, to which we cordially wish success. If, again, it is probable that not many of the great discoveries are left within the reach of ordinary instruments, it should not be forgotten that many telescopes of very superior character are now housed in private observatories; and that for them investigations are still reserved, whose delicacy is no bar to their importance, and which may be undertaken with a hope of success no longer chargeable with extravagance. Great cabinets may be unlocked by little keys. Minute researches may give the clue to discoveries of the broadest extent and deepest interest. The changes of the lunar surface; the internal motion of starry clusters; the parallax and fixity of nebulæ; the planetary attendants on the brightest stars, these are mere specimens of the magnificent arcana, whose solution may not be denied to human energy and perseverance. We may, remember, too, that if the telescope and the micromoter should be found unequal to the task, we have yet a new and most powerful method of investigation, the results of which are equally important and surprising—spectrum-analysis. The revelations of this beautiful invention may be said to be only beginning, and no man can foresee their end. What has already been done would have appeared as improbable as the reveries of Kepler, had it been predicted 50 years ago; and who shall say what may be the result of 50 years more of patient and energetic application? And what might not Kepler have said and done, had such an instrument of research been placed in his hands? We may suppose how his fervid imagination would have exulted in the prospects, and with what confident joy he would have repeated the memorable words which characterize one of his lofty aspirations, "Plus ultra est."

The Weston Patent Smoke and Gas Consuming Boiler Company.—This is the name of a new corporation formed to introduce the above-named boiler to the attention of railroad and steamship managers, engineers, master mechanics, and, in fact, to all using steam power. It is claimed for this invention that it will save ⅓ the fuel used in the generation of steam, besides completely consuming all smoke and gas—facts which are vouched for by the South Side Railway Company of L. I.; the Grant Locomotive Works, Paterson, N. J.; by H. Anderson, late General Master Mechanic of the Chicago and North-Western R.R. Company; the Superintendent of the Vulcan Iron Works, Buffalo, and several other prominent establishments where this boiler has been thoroughly tested and in successful operation during a year past.

The annual product of pins in the United States is 2,000,000 packs, each pack containing 3,300 pins, or a total of 6,720,000,000 of pins. This terrible quantity is the yield of 8 pin factories. One manufacturer's agent in Boston, according to the "Bulletin," sells every 6 months 1,000 cases of pins, each case containing 672,000 pins. The factory represented turns out 8 tons of pins per week. Hair pins are jobbed by the cask, and but one factory makes them, but that at the rate of 50 tons per month. The machine which cuts and bends the wire, makes 360 hair pins per min., ready for japanning. The production and consumption of pins increases 10 per cent. annually. A great part of the hair pins used are imported. After these figures, we can safely ask, What becomes of all the pins?—*Iron Age.*

What is Navigable Water?—A recent important decision of the United States Supreme Court establishes that a river is a navigable water of the United States when by itself or in connection with other waters it forms a continuous highway, over which commerce is or may be carried on with other States, or with foreign countries, in the customary modes in which such commerce is conducted by water. If a river is not of itself a highway by its connections with other water, and is only navigable between different places within the State, then the Court holds it is not a navigable river of the United States, but only a navigable water of the State. This is clear enough, and is worth making a note of.

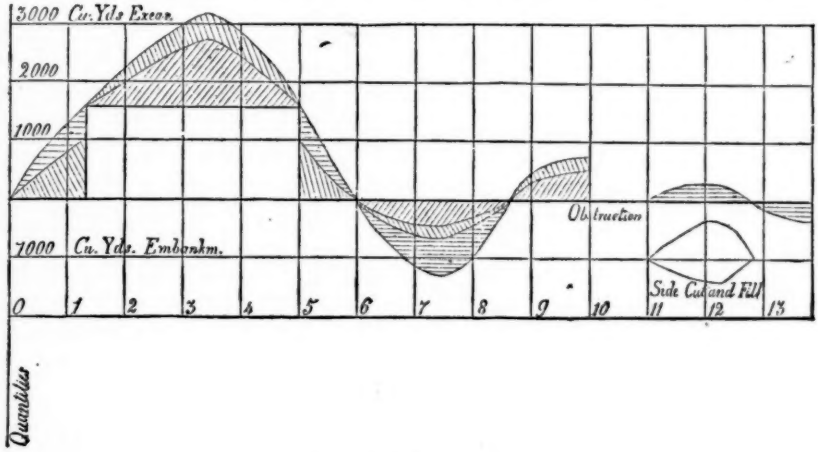
California has 2,307 miles of railway, and is far above some of the older States.

ON RECORDING EARTHWORK NOTES.

By H. KOCH, C. E.

Every railway engineer knows how important it is to have earthwork recorded in such a manner as to show, without calculation, what quantities either of embankment or excavation, whether of borrow or waste, lie between any two stations. We offer here a simple device to accomplish this end.

Represent the stations on an abscissa line, the earthwork quantities by ordinates, commencing with 0 at station 0, and representing the quantity of earthwork between this and the next station by an ordinate at the latter. Excavation is to be represented by measurements upwards, or by an increase of ordinate, and embankment in the opposite direction.



Explanation of Engraving.

Total work to be done represented by outside curve.

From station 0 to 1, 1200 yds. cut.
" " 0 to 2, 2340 "
" " 0 to 3, 3000 "
" " 0 to 3 + 20, 3030 yds. cut.

At 3 + 20, beginning of fill.

From station 0 to 4, 2800 cb. yds. cut.
" " 0 to 5, 1420 " "
" " 0 to 5 + 90, 0" "

Between 0 and 5 + 90 cut and fill are equal.

Between 0 and 6 or 5+90 and 6, 200 cb. yds. fill.
5+90 and 7, 1180 " "
7+40, 1300" "

At 7+40 fill changes into cut.

Between 5+90 and 8, 1060 cb. yds. fill.
8 + 60, 0" " "

Between 5 + 90 and 8 + 60 cut and fill balance each other.

Between 8 + 60 and 9, 480 cb. yds. cut.
10, 650 " " "

This cut to be wasted on account of obstruction.

Between 11 and 12, 320 cb. yds. cut.

Between 11 and 12 + 95, 0 cb. yds. cut.

Betwen 12 + 95 and 14, 320 cb. yds. fill.

Between 11 and 12, 600 yds. side cut and 280 side fill.

Between 12 and 12 + 95, 600 yds. side fill and 280 side cut.

The work of two different months is represented by the proper curves.

On first month, between 1 + 35 and 4 + 90, 1100 cb. yds. cut, worked in to fill; 350 cb. yds. left to be done yet.

Between 5 + 90 and 8 + 60, 420 yds. cut, worked in to fill; 780 left undone.

Between 8 + 60 and 10, 450 cub. yds. cut wasted; 200 yds. left.

On second month 1000 cb. yds. are taken from cut between 0 and 1 + 35 to fill between 4 + 90 and 5 + 90; work between 1 + 35 and 4 + 90 completed; 600 cb. yds. cut and fill left undone between 0 and 5 + 90.

Between 5 + 90 and 8 + 60, 220 yds. are moved from cut to fill and 600 left undone..

Between 8 + 60 and 10 work completed with 200 yds. cut, wasted.

If the extremities of the ordinates to a series of stations be connected by a curve line, the points where cut and fill balance will be shown by the intersection of the curve and the abscissa. The maximum points will show where cut changes to

fill, and the minimum where fill changes to cut. A break in the curve either above or below the abscissa line, indicates the necessity of wasting or borrowing respectively at that point.

The scale for the whole may be made convenient to the amount of work.

The work of different months over the same line may be represented by curves of different colors or shades.

The labor of drawing the above is very slight; the curve may be drawn on the same sheet as the length profile.

The accompanying sketch of a record of an imaginary earthwork will serve to explain the plan more fully.

LITHOFRACTEUR.

From "Engineering."

Those of our readers who have followed us in our series of articles upon the subject of explosive compounds will be aware that we have many which possess great power for work, but which are unsafe to manipulate. They will also remember that the aim has been for some years past to tone down the violence of these compounds either by effecting new combinations of old materials, or by introducing new ones, so as to combine perfect safety in handling, transit and storage, with thorough efficiency in action. The principal practical results which have accrued have been the production of gun-cotton and dynamite, the use of the latter being confined to the Continent, chiefly on account of the existence in England of the Nitro-glycerine Act, which virtually prohibits the transport and storage of compounds into the composition of which nitro-glycerine enters. Within the last week, however, we have had to add another to our list of safe yet violent explosives tried in England, and which bears the name at the head of the present article. Lithofracteur —literally stone-breaker—is the patented invention of Professor Engels, of Cologne, and is composed of nitro-glycerine as a base, gun-cotton, the constituents of gunpowder, some chlorates, and an infusorial earth. These substances are prepared in a special way, and blended together by special means, the details of these operations being known only to the inventor and the manufacturers, Messrs. Gerbrûder, Krebs & Co., of Cologne. The result of this combination is a black compound of the consistence of soft putty, which is made up into paper cartridges 4½ in. long by ⅞ths of an inch in diameter, and weighing 1¾ oz. each. When lighted in the air by ordinary means it simply burns out, leaving a light white powder as a residuum; but when it is ignited either in the air or in a closed chamber with a capped fuse, its full violence is developed. It is safe under all ordinary and even extraordinary circumstances of storage and transit, as recent experiments in England and lengthened use on the Continent have proved. And here we may mention that, although this is almost the first time we in England have heard of this substance, it has been made and extensively used throughout Germany for more than two years past. It was used by the Prussians against the French during the recent war, Herr Engels being the operator. After Fort Issy was taken the Prussians destroyed a number of French heavy siege guns by blowing off their muzzles with lithofracteur.

A notice of this material having appeared in the German papers, the attention of the mining world in England was attracted to it, and a correspondence ensued between the manufacturer and Mr. R. S. France, the lessee of some extensive quarries in England. The result was that arrangements were made for testing the new material, Mr. France offering the use of his quarries, and Messrs. Krebs carrying out the experiments. In order that full publicity might be given to the trials Messrs. Krebs invited the attendance of a number of scientific gentlemen, who met at Paddington on Monday morning last, and proceeded to Shrewsbury, near which town Mr. France's quarries are situated. The party consisted of Captain Harvey, R.N., the inventor of the torpedo bearing his name, Captain McEvoy, of the London Ordnance Works, Mr. Brown, of the chemical department at Woolwich Arsenal, who represented the Government upon the occasion, Mr. Cargill, C.E., and Messrs. Houlder, Hockin, Comyn,

and Farrell, gentlemen connected with mines at home and abroad. The experiments were conducted by Herr Engels, assisted by Mr. Perry, F. Nursey, C.E., who is the engineer, in England, to Messrs. Krebs & Co., the arrangements of the trip being excellently carried out by Mr. Kirkmann, of Cologne, on behalf of Messrs. Krebs. The experiments were commenced on Tuesday morning at the Nant Mawr quarries, which are about 23 miles from Shrewsbury. These quarries are being worked in a range of carboniferous limestone mountains extending from 20 miles to the west of Shrewsbury northwards to the coast. The workings are approached from the railway by a double tramway 500 yards long, laid at a gradient of 1 in 8 up to the summit. Here the 2 lines branch off into 15, running to the face of the work. The wagons of limestone are sent down the incline by gravitation, the full trucks bringing up the empties. The limestone is of a very fine character, and is much used in iron works as a flux, the top portion being burnt for lime, Mr. France having 16 kilns for that purpose, which he keeps well employed.

The preliminary experiment consisted in throwing a box containing 5 lbs. of lithofracteur from the top of the quarries at a height of a 150 ft. from the ground into the plateau below. The box was smashed and the cartridges were scattered about, but not one was exploded. A cartridge was then lighted by an ordinary fusee, when it burned slowly out. Another cartridge was then placed upon a block of stone and fired with a percussion fuse, when a violent report followed, and the top face of the stone was broken off. The power of the lithofracteur when confined was then exhibited by firing charges in the bore-holes of several blocks of stone, which were shattered into many fragments. The tamping in all cases was effected with water, thus proving the usefulness and reliableness of the compound in workings where wet ground was met with. Another point also proved was, that if a misfire should occur—and one or two did occur in the course of the experiments—the charge could be withdrawn—and another one inserted without removing the tamping. And here we may explain that the method of firing is similar to that adopted by Nobel with dynamite and Abel with pulped gun-cotton. The capped fuse is simply imbedded in the lithofracteur, the paper of the cartridge being tightly tied round the fuse. The next part of the programme consisted in firing a number of shots, both horizontal and vertical, in the face of the quarry. As these were more or less repetitions of each other, we need only notice a few of them, although they all gave extraordinary results. The holes were mostly bored under the direction of some of the mining gentlemen present, who, with the view of testing the compound to the utmost, selected the worst possible spots, some of which, they stated, gunpowder would not possibly touch. The first of these blasts was made with a 1 lb. 1½ oz. of lithofracteur placed in a horizontal bore hole 3 ft. 4 in. deep, and 1½ in. in diameter. A large quantity of the stone was blown out to the front, and the face of the rock was scaled and cracked over an area of 20 ft. 6 in. wide by 13 ft. high. A couple more shots were then fired simultaneously near to the last, the bore-holes were each 3 ft. deep, and were charged with 13½ oz. and 1 lb. ½ oz. respectively, and an immense face of rock was brought down. The best blast, however, was the last of this series; it was fired in a vertical bore-hole, 4 ft. 6 in. deep, on a ledge of rock, about 23 ft. from the level of the plateau below, 1 lb. 1½ oz. of lithofracteur being used. The explosion brought down at least 20 tons of rock, and loosened an enormous mass behind the bore-hole, the shot being one of the finest we ever saw with so small a quantity of material.

Some experiments were next made with the view of showing the disruptive effect of lithofracteur on iron, and for this purpose a 4 ft. length of 75 lbs. double-headed rail was laid on its side, being supported at each end at a height of 3 in. from the ground. A charge of 1 lb. 3 oz. of the compound was placed in a lump on the centre of the rail, and tamped with paper, three old sleepers being placed on the tamping, and fired with a percussion fuse. A startling report ensued, the fragments of the sleepers being sent in all directions, and on examination the rail was found much bent, and with one head cut through, and 11 in. of the web blown away in the centre. Had the supports been a little higher, so as to have left room for a greater angle of bend in the rail, both heads would doubtless have been cut

through. The experiment was then repeated with two similar lengths of rail to the last, placed one on the other on their sides, the charge being 1 lb. 5 oz. of lithofracteur. The under rail was 6 ft., and the upper piece 3 ft. 6 in. long, the height of the supports being increased to 1 ft. 6 in. Five pieces of old sleeper were placed over the charge, which, when fired, hurled them with a cloud of dust high into the air, scattering the débris far and wide. Both the rails were broken clean through, the halves being thrown far away from each other. The under rail was also cracked through both tables on one side.

So far, with the exception of one or two experiments at the first, the power only of the lithofracteur had been put to the test. It was now proposed to carry out an idea, which originated with Mr. France, to put the compound to the severest possible test in order to prove its behavior under the conditions of a railway collision. To this end he had an old railway wagon placed on the rails at the bottom of the incline, whilst at the top was another, in front of the buffers of which were fixed two cartridges, one on each buffer. Each wagon weighed about 1¼ tons, the buffers of both being of wood. The upper wagon being released, started on its journey of 500 yards on an incline of 1 in 8, the speed being of course very great when it reached the bottom. On arriving there the buffers fairly met, and both wagons were in a few seconds lying a heap of splinters and fragments, wood and iron being alike smashed up. On examining the wreck the lithofracteur was found smeared on the buffer heads and other parts of the wagons. No explosion having of course occurred. The possibility of an explosion in a collision, should two iron surfaces, or even an iron and a timber surface meet, was then suggested by Mr. Brown of the Royal Arsenal, and Mr. France, in a most spirited manner, ordered the experiment to be repeated, with the buffers of the upper wagon iron-plated. The iron-on-iron test was carried out by tying two cartridges on the top surface of each rail at a point about 50 ft. above the foot of the incline. Upon the upper wagon being released, it went on its way down the incline, but had only reached about half way when its high velocity caused a wheel to break, and the wagon went smashing and spinning over a steep embankment into the meadows below. No explosion occurrred here, but the party were unexpectedly gratified by witnessing the representation of another class of railway accident.

Nothing daunted, Mr. France ordered out another victim to scientific research, and a fifth wagon was doomed. The buffers were iron-plated, and the cartridges were fixed in front of them as before. When once started from the summit of the gradient it rushed downwards, passing in its course over the cartridges on the rails. Two semi-explosions occurred, such as would be produced by striking a percussion cap with a hammer on an anvil. When the descending wagon reached the stationary one it smashed into it, and they toppled over together, another slight explosion being heard. The buffer plates were found some feet from the line, with pieces of the cartridge paper and some of the lithofracteur adhering to them, portions also being spattered over other parts of the framing. On examining the rails the greater portion of the compound was found to have been spurted about, one of the cases remaining tied to the rail, and the other having been carried some yards down the line. The explosions were occasioned by the ignition of that portion of each cartridge exposed to the force of impact, the remainder not having been exploded nor burned. This is borne out by the fact that on one rail we found a smear of lithofracteur, 7 ft. 6 in. from the cartridge case, in the centre of which was a small white spot. A careful examination of this spot proved it to be exploded lithofracteur, and 7 ft. 6 in. being the exact circumference of the wheel at the tangent of its cone with the rail, there could be no doubt that the wheel had picked up a piece of the compound, and, on completing its next revolution, deposited it on the rail, an almost inappreciable portion exploding at the point of contact. These experiments concluded the day's proceedings, after which the party returned to their headquarters at Shoeburyness. The experiments were resumed on the following day at the Breidden quarries in a different kind of stone, and some submarine experiments were also carried out, but want of space obliges us to defer a notice of these until next week.

Mr. France's object in having these last

experiments made was to test the effects of concussion upon lithofracteur. He considered this essential, in order to meet the objections raised by railway companies to the transit of explosive compounds, and he deserves the thanks of all interested in mining matters for the convincing manner in which he has demonstrated the harmless character of lithofracteur. The great drawback in many cases at the present time to efficient mining and quarrying is the lack of such substances as these, which above all others are calculated to promote the development of this class of property. It is to be hoped that the stringency of the Nitro-glycerine Act will be somewhat relaxed, now that that dangerous substance has been proved to be so safe and harmless under all possible conditions except those of actual work.

THE RELATIVE VALUE OF DIFFERENT KINDS OF FUEL.

From the "Colliery Guardian."

The evolution of force by heat, with motion as a resultant, is one of the most important of the laws of natural philosophy. Wherever motion occurs, heat must be recognized as the primary cause. The sum is the original source in the production of heat, as shown by its influence upon tides, winds, and the support of the life of plants and animals. Its effect is curiously displayed on the natives of the tropics, in supplying them with such sustenance by natural heat as to make very little food requisite; whilst towards the frigid zone, the use of carbonaceous food becomes more and more necessary. The elements hydrogen and carbon, in combination with oxygen, evolve a greater amount of heat than any other elements. As hydrogen is not attainable, substances such as wood, peat and coal, which contain a large proportion of carbon, are chosen as the materials which by combustion produce heat. In the construction and building up of organic life, a certain amount of energy is invested by the sun's rays. In combustion this energy re-appears as heat. This, in a few words, is the true theory of heat. The more a substance is capable of absorbing and rendering latent a certain number of units of heat, the more it is capable of giving out, when consumed with oxygen, appreciable and useful energy.

It is important to observe the comparative results available from what may be termed "current-going" heat, as developed by the work of a horse, and conserved heat, as shown in the work done by the combustion of fuel. This is demonstrated by the fact that the combustion of a single pound of coal in one minute is equal to the work of 300 horses for the same time. The extent to which any country is influenced by the possession of coal fields is evidenced by the following singular statement: Taking 10 lbs. of coal per day, or 1½ tons per year, as applied to the production of mechanical power through the agency of steam, to be equal to the labor of a man, every 10,000,000 tons of coal adds to the productive labor of England, a force equal to the exertion of 7,500,000 fresh men annually. A beautiful example of nature's constant law of "no waste" is afforded in considering the combustion of fuel. The exact amount of carbon which is set free by combustion, either of fuel or animal life, is again stored up in animal vegetation. The results of combustion, viz., carbonic acid and water, return to the earth to support the life of plants and trees, which absorb the carbon from the carbonic acid, setting free the oxygen again for the support of life or combustion, and obtain hydrogen from the water in the atmosphere. Each element retains its calorific power, and thus the fuel of the future is undergoing a constant process of formation from the results of the combustion of the fuel of the present.

A brief description may now be given of the different varieties of fuel used in the British Islands.

Table I.

Name.	Where found.
1. Wood	
2. Charcoal	
3. Peat	Ireland and moorland districts.
4. Lignite	Germany and Devonshire.
5. Bituminous coal	All English coal fields.
6. Anthracite	Wales.
7. Coke	

I. Wood.—This is the original form of

fuel. The objections to its use are, first, the comparative small amount of carbon it contains, varying from 40 to 53 per cent.; second, the amount of moisture it generally contains—the value of damp wood being $\frac{1}{3}$ less than dry; third, the surplus of oxygen it contains, which retards combustion. Wood is only used as fuel when it is abundant and coal is scarce.

II. Charcoal.—Charcoal is wood freed from its volatile ingredients. Owing to the scarcity of wood and inconvenience of manufacture, charcoal is only used as fuel when coal is scarce, or when a hot fire is desired in small compass. It is more pure than coal, but absorbs moisture to the detriment of its heating power. The following is a scale of the comparative heating value of different woods before and after being made into charcoal, No. 1 being the best:

Table II.

Wood.	Charcoal.
1. Fir	Oak.
2. Poplar	Birch.
3. Birch	Poplar.
4. Sycamore	Fir.
5. Ash	Elm.
6. Elm	Sycamore.
7. Oak	Ash.

There is much more variety in the wood than in the charcoal, the former varying from 1,000 to 790, and the latter from 1,000 to 985.

III. Peat.—Peat, resulting from the decomposition of vegetable matter in marshes, has about $\frac{3}{4}$ the heating power of coal, and is used almost solely in the localities where it is found. It is difficult to obtain it free from earthy particles.

IV. Lignite.—This is an imperfect coal formed by wood buried in moist earth, and thus undergoing one of the changes leading towards the production of coal. It occurs rarely in the British Islands, but is used extensively in Prussia and Austria. It contains when found a large percentage of water, which is difficult to eliminate. It will be seen by Table IV. the extent to which the proportion of oxygen decreases in the change from wood to coal—lignite being the intermediate stage.

V. Bituminous Coal.—This is the most important fuel, and presents the varieties of splint, caking, open-burning, and cannel coals. These are the coals used for steam, gas, household purposes, and for iron smelting, in the form of coke or otherwise. The splint and coking coals form the chief produce of the northern counties. Splint is a caking coal with a dull appearance. The open-burning coal also bears the name of "cherry" and "soft coal." The difference between the caking and the open-burning coal is probably due to the larger proportion of bitumen in the former, and of oxygen in the latter. Cannel coal is most valuable for gas purposes, a maximum proportion of hydrogen, and a minimum proportion of oxygen, being required for this. This coal has probably been originally formed from the densest vegetation. Its conchoidal fracture, lustreless appearance, and cleanliness to touch, are well known properties. The following is a table, exhibiting the relative quantities of heat given off by the same weight of each of the varieties of bituminous coal, from experiments made by Dr. T. Richardson:

Table III.

Species of Coal.	Locality.	Relative quantity of heat given out by the same weight of coal. Edinburgh=100.00.
Splint	Newcastle	110.34
"	Glasgow	115 12
Cannel	Lancashire	117.83
"	Edinburgh	100.00
Cherry	Newcastle	116.68
"	Glasgow	112.12
Caking	Newcastle	122.12
"	Durham	114.98

VI. Anthracite.—The coals belonging to this class are characterized by containing a much larger amount of carbon than any other variety, and but very little volatile substance. This coal is generally found in regions distinguished by igneous action, as in Wales and the Alps, and is, probably, bituminous coal, altered by transmittent volcanic heat into a natural coke. In Wales, the same bed may be traced from where it is bituminous to where it is anthracite. The smokeless nature of this coal makes it of great value as a steam coal, there being so little gas, the setting free of which usually carries off a portion of carbon as smoke, to escape.

VII. Coke.—When coal is freed arti-

ficially from the volatile gases, coke, which when produced from good coal is nearly pure carbon, is the result. The process of making coke is also resorted to for the purpose of removing the sulphur from the coal, and for producing a strong compact fuel for iron smelting. The component parts of several well-known combustibles are shown in the following table, in which may be observed the chemical decomposition of wood in its gradual conversion to coal :

Table IV.

	Wood.	Peat.	Bovey Lignite.	Boghead Cannel.	Wigan Cannel.	Newcastle Caking Coal.	South Wales Anthracite.	Durham Coke.
Carbon.....	510	540	663	631	801	849	904	932
Hydrogen.....	53	52	56	89	55	45	33	7
Oxygen.....	417	282	229	70	81	67	30	9
Nitrogen.....	..	23	6	2	21	10	17	13
Sulphur.....	..	6	23	10	15	6	..	..
Ash.....	20	97	23	198	27	23	16	39
Total.....	1000	1000	1000	1000	1000	1000	1000	1000
Coke, per cent..	213	293	308	302	604	750	921	..
Specific gravity.	.81	.85	1.13	1.20	1.28	1.28	1.39	..

It will be seen from the above analyses that the proportion of hydrogen in fuel varies very slightly in passing from one condition to another, whilst the quantity of oxygen is very materially less as the process of coal formation progresses. This is the simple cause of the higher calorific power of coal as compared with wood and peat. The greater portion of the oxygen is set free by natural distillation, and hence carbon and hydrogen constitute a large proportion of the residue.

The following table (No. V.) shows an analysis of the different coal found in England and elsewhere.

Having now shown the chemical composition of the chief descriptions of fuel, it will be desirable, for the purpose of illustrating their distinctive value, to compare their calorific power, and that of their constituents. This is done in several ways in the following table (No. VI.), on referring to which it will be seen that hydrogen has by far the highest heating power; hence some coal has more capacity for generating heat than pure carbon. The whole of the hydrogen, however, is not utilized, since, when oxygen exists with hydrogen in any fuel, they form water in the act of combustion, and only the surplus is available.

Table V.

	Northumberland and Durham.			South Wales.		Derbyshire house and coking.	Scotland. Eglinton.	Lancashire. Ince Hall Arley.	Borneo.	Van Diemen's Land.	Trinidad.
	Best house.	Steam.	Coking.	Steam.	Anthracite.						
Carbon.....	843	787	868	807	923	799	801	826	703	802	652
Hydrogen.....	55	60	50	57	30	48	65	59	54	30	43
Oxygen.....	62	101	52	24	26	110	80	74	192	48	217
Nitrogen.....	21	24	10	13	6	12	16	18	7	14	13
Sulphur.....	12	15	9	44	..	7	14	8	12	19	7
Ash.....	7	13	11	55	15	24	24	15	32	87	68
Total.....	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Coke, per cent.....	750	606	721	751	921	578	549	640	...	...	....

The difference in value of the several samples of coal is interesting, and seems in favor of the Welsh and Newcastle coal, which are the only coals having a higher heating power than pure carbon. It will be observed that with the exception of the Derbyshire coal, the calorific power varies with the proportion of carbon. In the case of Derbyshire coal, the oxygen is in such such excess that it absorbs a a large portion of the hydrogen to form water. For the same reason, the heating

Table VI.

	Composition of Fuel.			Calorific Power.			
	Carbon.	Hydrogen.	Oyxgen.	Heat in degs. F. to which 1 lb. of water will be raised by 1 lb. of the fuel in conjunction with oxygen.	Relative.	Lbs. of water heated from the freezing point to 212° F. by 1 lb. fuel.	Lbs. of water at 212° F. converted into steam by 1 lb. fuel.
Hydrogen	...	1.00	...	62,032	4,265	344.6	62 6
Light carburetted hydrogen	.75	.25	...	23,513	1,816	146.7	26.7
Olefiant gas	.86	.14	...	21,344	1 466	118.5	21.5
Carbon burning to carbonic acid	1.00	...	...	14,544	1,000	80 8	14.7
Carbon burning to carbonic oxide	1 00	...	...	4,453	306	24.7	....
Carbonic Oxide	.43	...	.57	3,116	214	17.3	3.1
Coal:							
Average Welsh	.888	.048	.041	14,833	1,020	82 4	15 0
" Newcastle	.821	.053	.057	14,796	1,017	82.2	14.9
" Scotch	.785	.056	.097	14,150	973	78.6	14.3
" Derbyshire	.795	.049	.101	13,919	956	77.3	14.1
" Lancashire	.779	.053	.095	13,890	955	77 2	14.0
Coke	.94	.0004	.007	13,197	900	72 7	13.2
Peat, dry	.60	.06	.81	10,152	694	56 4	10.3
Wood, dry	.50	.06	.41	8,029	551	44.5	8 1
Phosphorus	...	...	...	13,500	929	75 0	13.66
Naphtha	...	...	...	13,208	909	73 2	13.4
Alcohol	...	...	...	12,931	889	71.8	13 1
Sulphur	...	...	...	4,032	277	22.4	4.1

power of coke is less than that of coal, owing to so large a proportion of hydrogen being driven off in the manufacture of the coke. The heating power of marsh gas, or light carburetted hydrogen, may be said to present an unfair comparison with coal, since the heating power of 1 lb. of coal will be considerably greater than the power of the gas produced from it by distillation. This also applies to coke. One pound of coal having a heating power of 14,796, when made into coke, would have a power, supposing the production of coke to be 60 per cent., of only $13,197 \times .60 = 7,918$.

The presence of oxygen in fuel acts in a twofold manner in reducing the calorific power, by reducing the actual amount of carbon and hydrogen, and by rendering part of that amount ineffective for generating heat.

Hydrogen in fuel is only useful for the development of heat, when the proportion of it contained in any combustible is in excess of $\frac{1}{8}$ of the quantity of oxygen contained in the same combustible.

A New Atlantic Steamer.—One of the largest Atlantic steamers ever built has been floated from the shipbuilding yard of Messrs. Laird Brothers, Birkenhead. The vessel has been named the Spain, and is to form one of the National Steamship Company's line between Liverpool and New York. Her length is 437 ft., her breadth of beam 43 ft., she is of 4,900 tons burthen, and has accommodation for 1,200 first-class and 1,400 steerage passengers. The engines of the Spain are stated to be the largest ever constructed on the compound principle, and the vessel is expected to have great speed both under steam and canvas.

The General Post-office of Great Britain has decided to at once extend telegraphic communication to Stornoway, in the Western Hebrides. The submarine cable to be laid across the Minch will be some 28 nautical miles in length, and submerged in water of the average depth of 50 fathoms.

ON COMPLETING THE LAUNCHING OF SHIPS WHICH HAVE STOPPED ON THEIR LAUNCHING SLIPS.

By WILLIAM BRAHAM ROBINSON, Esq.

From the "Journal of the Society of Arts."

The Cæsar, a 90-gun two-decked wooden ship, having been prepared for launching, was attempted to be launched on the 21st July, 1853, at the Royal dockyard, at Pembroke dock, but after she had slid down the launching ways some '80 ft., and thus immersed her after-part into the water at high tide, she stopped entirely,* and all the subsequent efforts made that day to move her were of no avail. The declivity given to the launching-slip was the usual amount, and the plank and material used in the ways were also of the usual description. The plank on the launching-slip was pitch pine, a material commonly applied to that purpose at Chatham-yard, though it had not been used at Pembroke for some years previous in launching heavy ships.

Between the 21st and 26th July, some small hollow vessels, built for the purpose, and a few casks, etc., were put under the ship's bottom, below high-water mark, with the view of reducing the weight of the ship on the ways, and at the time of high tide efforts were then made, by means of purchases, to pull the ship off, but all these measures were unavailing.

A careful inspection of the work at low water the night after the ship stopped, and on subsequent occasions, convinced me that the real cause of the failure on the 21st July was the want of a sufficient and proper lubricant between the sole of the ways and the launching-slip, and the sliding surfaces being made too smooth by planing them. Acting on this opinion, and observing that the ship's stern was sufficiently immersed in the water, when the tide was up, to admit of proper vessels being placed so as to lift the ship abaft, I advocated persistently before the then master-shipwright the necessity of adopting the unique plan of building camels for breaking the too close contact that appeared to be established between the sliding-ways and the launching-slip, by lifting the stern of the ship so as to take its weight off the launching-slip. On Tuesday evening, the 25th July, it was determined to build 3 large camels for this purpose. I thereupon caused to be laid off in the mould-loft, in a few hours, a camel to fit each buttock, 72 ft. long, to be planked with 4-in. fir plank, and one for the stern 20 ft. sq. in section, and 48 ft. long to be built of 5-in. fir plank, the collective lifting power, when properly in place, being estimated equal to 1,100 tons. The artificers were set to work from 3 A.M. to 8 P.M. cutting out plank, etc., for these camels, no suitable material being in the yard, and in the incredibly short period of 9 days these large vessels were built and launched, and on the following day, the 5th August, they were got partly into place, under the very great difficulty of having to secure the after one with nothing firmer to rest upon than soft mud. On two subsequent tides, the camels being only imperfectly shored down, and therefore only partially in action, the ship was moved, when a pulling power was applied, 9 ft. and 45 ft. successively; and at last, on the evening tide of the 17th day after the ship had stopped on the slip, the camels having been properly kept down in their places by bearers put out at the quarter-ports on the lower deck, and shored to the main deck upper sills to keep in place the quarter camels, a similar plan having also been adopted to keep down the stern camel, without any pulling power being applied, the ship, about one and three-quarter hours before high-water, abandoned her unworthy connection with the land, and glided gracefully into the haven, amidst the rejoicings of all the people in Pembroke dock. An examination of the launching-slip after the ship had left it, proved that the opinion I had formed had been founded on no hypothetical reasoning, since the absence of grease was apparent enough, and the too great smoothness of the sliding surfaces was equally evident. The camels, it may be added, which have been briefly described, were provided with valves for reducing their lifting power, but it was not found necessary to use them.

* I was not the responsible officer engaged on the launch.

During the 17 days and nights the ship remained on her slip, it was pleasing to observe the interest every man in the yard appeared to feel in the preparations making to get her off; and they worked most willingly day and night, the water drinkers coming out of the trial fresher certainly than many others.

On the 9th August the ship was docked, the stern camel having been kept in place, and 70 tons of ballast having been put on board forward to trim the ship. The sheer of the ship, which had broken when the ship was on the launching-slip about 1 6″, returned in great part to its normal form on docking the ship, and it was held there by the introduction of "double fastenings" in the wales, and by an admirable method of coaking and "keying up" the iron diagonal riders proposed by the then master-shipwright of Devonport yard.

With the experience of the case of the Cæsar stamped on my memory, I surveyed the condition of the Northumberland when she stopped on her launching-slip on the 17th March, 1866, as the Cæsar had done, and I at once observed that her position was just such as would require her to be dealt with in the same way as the Cæsar had been—with this difference, that in the case of the former ship, a very rigid iron hull, which would keep the ways straight and to their form, had to be dealt with, instead of, as in the case of the Cæsar, a flexible body, which would bend, if not well supported, to a large extent before breaking.

On the afternoon of the day on which the Northumberland stopped on her launching-slip (the 17th March, 1866), after I had carefully examined into all the circumstances connected with the position the ship was in, I inquired for the office, and obtained after some trouble a quarter of a sheet of foolscap paper, upon which I briefly described the experience I had acquired in the case of the Cæsar, and proposed lifting the ship abaft by means of camels built for the purpose, or suitable small ships which might be found lying in the river; and this definite proposal I put into the hands of Mr. Lungley, the then manager of the company, when that gentleman was standing alongside the ship.

On a subsequent day I mentioned the subject of the memorandums referred to, to the chairman of the company, but notwithstanding this, nearly the first action taken was to lay a second launching-slip alongside the original one, at a less declivity than the original slip had been laid at. This was done I believe with the view of sliding the ship down far enough for her weight to come upon the slip with the lesser declivity. Together with this certainly very novel arrangement, some means for lifting the ship abaft by mooring lighters, etc., was provided; and on the 2d of April, all being ready, an attempt was made to complete the launch of the ship; but it failed, as I had predicted it would when speaking to the gallant chairman of the company at the head of the ship, just before the event.

Immediately after this failure my proposed plan of lifting the after-part of the ship was adopted, and measures were taken to build the requisite camels in the two neighboring Royal dockyards, Woolwich and Deptford, where the usual willing exertions were exhibited by officers and men; and the four camels—two for each quarter—were built in a very few days; and they were secured in place by the 17th April (just one month from the first attempt to launch the ship being made), and on the rising of the tide they lifted the ship abaft off the launching-slip, when she glided into the river without the help of the large pulling power which had been provided.

The camels which have been referred to were admirably detailed by the officers who built and prepared them, and the valves were most successfully managed on the day of the final launch, so as to prevent the camels from lifting the ship above the ribands on the launching-slip.

The day after the ship left her launching-slip, I, at low water, inspected the slip, the plank of which was oak, not fir, as in the case of the Cæsar, and saw enough to convince me that my first impression had been a right one, namely, that the ship had stopped in the first instance mainly for the want of a proper and sufficient unguent on the ways and slip.

The forces in action when a ship's stern is lifted under similar circumstances to those which obtained when camels were used to lift the after-parts of the Cæsar and Northumberland may be illustrated

as follows, by which it will be seen that it could scarcely be necessary to provide a large pulling power in addition to the lifting power of camels :—

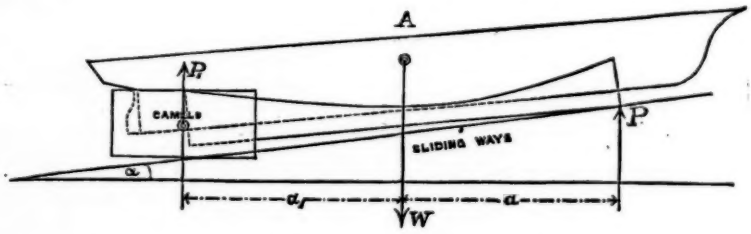


Fig. A, represents a ship in the position I have been describing, and it will be seen that the forces acting upon her are as follows :—

1st. Weight, W, acting downward through the centre of gravity of the ship.

2d. The upward thrust, P_1, of the camels, which is equal to their buoyancy, and acts through the common centre of gravity of their displaced volume.

3d. The re-action, P, at the fore end of the slipway.

The force which acts to push the vessel down the slipway, we will call F, and this will be equal in amount to—

$$P \sin L - \mu P_1 \cos L$$
$$= P (\sin L - \mu \cos L).$$

When μ is the coefficient of friction, and depends upon the kind of unguent used, and L is the angle of inclination of the sliding plank.

By reference to the figure it will be seen that—

$$P = W \frac{a}{a + a_1}$$

and as a will under most circumstances be nearly equal to a_1, we may take—

$$P = \frac{W}{2}$$

and we shall then have—

$$F = \frac{W}{2} (\sin L - \mu \cos L).$$

If the stern of the ship were not lifted, but her whole weight rested on the slipway, the force acting to push her down the slip would be—

$$W (\sin L - \mu \cos L).$$

or double what it is in the present case.

The advantages obtained by the use of camels are due to the fact that they take all the weight of the ship off the bilgeways, except at the extreme fore-end, so that the after-part is lifted clear of any obstruction that may exist ; or, where the grease used is bad or insufficient in quantity, the adhesion of the surfaces in contact is overcome, and they are left free to slide upon each other.

To the foregoing it may be added that due consideration should at all times be given in preparing the "launch" of a ship to the relative weight of the ship and area of the soles of the ways, declivity of launching-slip, and to the time it is intended the ship shall rest in her cradle before the launch takes place, and then finally on the kind and quantity of grease to be used between the sliding surfaces. All these points affect the *stiction* to be overcome in launching the ship.

ORIGIN OF GRAPHITE.—Prof. Wagner ascribes the deposits of graphite, plumbago, or black lead, which are found in a great variety of rocks of different geological periods, to the decomposition of cyanogen, which is a combination of carbon and nitrogen, or of the cyanides. In several chemical processes used in the arts, graphite is formed artificially; and it is not impossible that this expensive mineral, the best specimens of which are now brought from the island of Ceylon, may be produced artificially in such quantities as to be made available in several branches of manufactures where this mineral is indispensable. Chemists, however, have not yet accepted Prof. Wagner's explanation, or any other, as to the natural production of graphite.—*Iron Age.*

LONDON is now in direct telegraphic communication with Hong Kong.

THE MAKING AND REPAIRING OF ROADS.

From "The Building News."

A road should be considered as a structure having two essential parts, a foundation and a wearing surface. The duty of the first is to keep up the second to its work, and may be made in any way that satisfies the one condition of unyielding firmness. It has been sometimes said that a slightly yielding or elastic foundation is better than a rigid one; and if that elasticity could be had at a sufficient depth below the surface it might be so, but practically it is not to be had, and the danger of trying to make the foundation elastic far exceeds the objection of rigidity.

A great deal of unnecessary discussion used to be indulged in as to whether the plan of making the foundation which was adopted by Mr. Telford or that practised by Mr. Macadam was the better. Telford's plan was to pitch the road-bed with rough stones, set closely by hand, with their broadest edges downwards, and their greatest length crosswise of the road, the breadth of the upper edge of any stone not exceeding 4 in. All the irregularities of the upper part of the pavement were broken off by the hammer, and the chips packed by hand and wedged into the interstices. The depth of the stones when finished off was 7 in. in the middle part of the road, 5 in. at a distance of 9 ft. on each side of the centre, 4 in. at 12 ft., and 3 in. at 15 ft. The surface thus formed a curve, having a rise of 4 in. in the centre. This is clearly a good foundation, but it is somewhat against it that the bed is flat, and that if water should percolate through the top coating and through the pavement it would, on some kinds of ground, as upon clay, weaken its bearing power; but if the ground is porous, as sand or gravel, or rocky, as it was on most parts of the great Holyhead road made by Mr. Telford, this objection to a flat bed does not arise. Whenever the bed, however, consists of clay or other impervious ground, the bed should be sloped downwards from the centre to the sides to about the same extent as Mr. Telford allowed—viz., 4 in. in a width of 15 ft., so that water may drain away. Two straight slopes for this purpose are better than a curve. Macadam, on the other hand, considered this pavement foundation to be unnecessary, and insisted that the native soil, properly formed and drained, must be considered to be the foundation, and carry the weight of the traffic; and that whatever stone may be laid on is only to preserve this foundation from injury, and its thickness should be regulated only by the quantity of material necessary to form such a protection, and not at all by any consideration as to its own independent power of bearing weight; and that it is an erroneous idea that the evils of an undrained, wet, clayey soil can be remedied by a large quantity of materials.

But what makes the discussion upon the two methods of little use, is the fact that Macadam's own practice approaches that of Telford, for on laying on the broken stone he was careful to lay first a layer 3 in. thick, and have that pretty well consolidated by traffic before any more was put on; and this and the succeeding layer may be taken to stand in the place of the pavement of Telford. The native surface having been formed, Macadam's system was to lay first a layer of 3 in. of clean broken stone on a dry day, and after the traffic had almost, but not quite, consolidated it, the ruts being kept raked in as soon as they are formed, a second layer of 3 in. was laid down in a wet time, moisture facilitating the union of the two.

Then the third layer forms the top coat, and carries the traffic. Macadam insisted strongly on the necessity of the stones being clean and angular, whereby the angles interlock with each other and form a solid structure; whereas, if other material be admitted under the pretence of binding, it prevents this close union, absorbs water, and in frost disrupts the mass. Macadam's method of laying the foundation—that is, the first two layers of broken stone—has the disadvantage that in wet clayey ground the traffic forces the stones into the ground, and it rises through the interstices, although Macadam maintained that draining would prevent this. Draining, however, cannot altogether prevent it, and it is only to be prevented by selecting a dry time for laying down the first layer of stone. The first layer being accomplished, the second becomes easy. Telford's pavement is easy under any

circumstances and in any weather, but is more expensive. It has the advantage, however, of distributing the weight on the surface over a large area of foundation, for if we take a wheel touching 2 sq. in. of the surface, the pressure is carried down to the foundation stones, which rests on a broad surface of, say, 10 in. by 5 in., or 50 sq. in., so that the bearing surface is multiplied 25 times. To prevent the displacement of the foundation stones, the carts bringing the stone were not allowed to pass over them.

The foundation, then, having been laid, whether of one or the other kind, or in any other way, so that it be unyielding (in the manufacturing districts engine ashes are largely used, and make a very good foundation, laid on 7 in. deep in two layers, the traffic being allowed to pass over them before the top coat is put on), the wearing coat has then to be put on, and now the quality of the stone comes into question. The most durable stone is that which is toughest. Mere hardness is no test of quality for the purpose of road making. Flint is hard enough, but it is almost the worst material for a road, because it has no toughness.

In his "Discourse on the Study of Natural Philosophy," Sir John Herschel says: —"Hardness is that disposition of a solid which renders it difficult to displace its parts among themselves; thus steel is harder than iron. The toughness of a solid, or that quality by which it will endure heavy blows without breaking, is again distinct from hardness, though often confounded with it. It consists in a certain yielding of parts, with a powerful general cohesion, and is compatible with various degrees of elasticity."

The most useful stone is that which is most difficult to break up. Such is the blue granite of Guernsey; a trap rock found at Clee Hill, in Shropshire (the Clee Hill Dhu stone); a stone got near Macclesfield, in Cheshire; the whinstone of the north of England; the Penmanmaur stone from Wales; beach pebbles and boulders; a stone brought in the bottoms of ships as ballast from Bombay; another from Port Philip; and other such kinds of stone. Stone of secondary quality is the carboniferous or mountain limestone, and the harder sandstones. Broken flints form a third quality, and the lowest is flint gravel. This last is unfit for anything but by-roads. It is very extensively used in the south of England for all kinds of roads, but it is not economical to use it where there is considerable traffic. The comparison of the strength of different kinds of stone by the steady weight that pieces will bear before crushing is not admissible in the case of road-stone, for the weight it has to bear is not a steady one, but one of impact. Most of the roads round London are made with flint gravel, and in the coaching days there was a select committee of the House of Commons upon highways, and before that committee evidence was given that for the first few stages out of London it required ten horses to do the same work that eight did beyond them, and that the horses out of London, although better animals to begin with, were worn out in four years, while on other roads they would last six years. It may be laid down as an axiom that it is more economical to bring good materials from a distance than to use inferior ones obtained close at hand. Thus, in London, for the heaviest traffic it is more economical to use Clee Hill Dhu stone at 16s. 3d. per ton, Enderby stone at 15s. 6d., and Guernsey granite at 15s. 6d., than any other stone, although the prices are less; and at Manchester they use the Penmanmaur stone at 12s. per cubic yard rather than other stone which might be had much nearer. The thickness of this top coat is not of much consequence; it is only required to protect the foundation from the action of the traffic; and may be any thickness that is convenient; and the most economical thickness will be determined by considerations of labor—how much it costs to lay down a coat of 2 in., one of 3 in., one of 4 in., and if 6 in. be put on it must be put on in two layers of 3 in. each, and then how much will that cost? And each of these costs must be compared with the standard of wear, which will be the same whatever thickness the coat of stone may be; and in this, as in many other things, the middle course will more often be right than either extreme, and it will generally be found that from 3 to 4 in. is the best thickness. It is true that on such a foundation as Telford's more than this is required above the pavement, or the road would be too rigid; and accordingly Telford directed that 4 in. of broken stone should intervene between the pavement and the top coat of stone.

"The middle 18 ft. of pavement is to be coated with hard stones to the depth of 6 in.; 4 in. out of these 6 in. are to be first put on and worked in by carriages and horses, care being taken to rake in the ruts until the surface becomes firm and consolidated, after which the remaining 2 in. are to be put on." The next thing to be considered is the size to which the stone of the top coat shall be broken. Both Telford and Macadam said, to such a size that its longest dimensions should be not more than 2½ in., which would be, for average materials, cubes of about 1½ in., and Macadam further directed that no stone should be more than 6 oz. in weight. But neither dimension nor weight can be accepted as logically defining the proper size, because that depends upon the nature of the material. To reduce flint or sandstone to the dimensions proper for traprock and granite, would be to insure their immediate grinding up and removal from the road. But there is no doubt that for the better kinds of stone the size can hardly be too small, so long as they are broken to a uniform size, and here the superiority of hand-broken stone over that broken by machine is very evident. Hand-broken stone is more uniform in size, and approaches more nearly to the best form—the cube—than can be had with any machine, for while the machine breaks up some of the stone into too small fragments, it cracks many of the pieces of the right size, and thus when the traffic comes over them they split, and they are split also by the action of frost. We believe the French engineers disregard the cleanliness and uniform size insisted upon by Macadam, and allow even dust to be mixed with the clean angular stone, but we are convinced that this is a mistake. The object of having the stones clean and free from extraneous matter, is that they shall interlock, and the angles adjust themselves so as to come home, stone to stone, and so form a solid body; but when dust or other substance is allowed to come into the cavities they cannot do so, and are thereby rendered less stable. It is probable that the success of the French engineers in making roads is due to the attention they pay to rolling the surface; but even by that means they cannot force the stones into contact when dust intervenes. Breaking stone would seem to be a simple thing enough, and one that any able bodied-man may do as well as another, but it is not so. In the first place, it requires a particular kind of hammer. The head must be of solid steel. The shape of the face of it must vary with the kind of stone to be broken. The handle must be pliable, and not a stiff piece of wood—it must therefore be a green stick—and hazel or ash plant is used. Then a stone-breaker must know where to hit the lump he is to break, and where he shall hit it depends on the nature of the stone. A great deal of strength is wasted by men unaccustomed to stone-breaking, who take up the work for the first time, and work with tools of the wrong kind.

The shape of the surface of a road is important. There are three forms of surface; one, the most common one, a curved surface, having a rise from the water channel to the crown of 4 in. or 6 in.; the second form is the straight slope on either side of the centre; and the third the hanging road, where the slope is all to one side, the road having only one water channel. In the latter case it is generally dictated by local circumstances, but the other cases are general. The higher the crown is made above the water channels for the sake of getting the water quickly off the road, the more is the traffic restricted to the centre of the road, for nobody will drive on sidelong ground if he can get a level footing. There is not much difference between the two forms, for if the road be made at first with straight slopes it will soon become worn down at the apex into something like a curved form. But there is a good deal to be said against the practice of raising the centre of the road too much in either way, for the object ought to be to get the traffic spread equally over the width of the road, and thus we come to the conclusion that as little rise as possible should be given to the crown; and 3 in. in 10 ft., or 1 in 40, is sufficient to allow the water to run off, and if it takes a longer time to run off such a road than it does on a more rounded one, that is of less consequence than unequal wear.

The road having been formed, it has to be maintained as nearly as possible in its original form, There is no stone that is of exactly a quality throughout, and the reason why a road wears into holes is that the softer parts here and there are

worn away before the rest, leaving the hardest portions of the stone standing up in ridges or knobs, and when this attains to a sufficiently objectionable degree the holes are to be filled up with new stone broken very small, and no more stone used than is sufficient to bring the surface up to the level of the adjoining unworn portions of the road.

The common error is to put too much stone on a place that wants some mending, and many roads have been raised considerably above their original level. The object should be to keep up the thickness of the metalling as nearly as possible to that it originally had. This cannot be done absolutely, but it can be approximated to; for instance, if the original thickness of the top coat be 4 in., 1 in. of the best part of the material, as well as that used for patching, will be worn away in, say, twelve months, leaving the thickness no where more than 3 in. It will be proper then to repair the road with a fresh coat of stone, raising the thickness to, say, 5 in., which would then allow two years' wear before another coat of stone would be required.

Whenever a new coat may be necessary, the surface of the road is to be picked up to a depth of 2 in., the surface readjusted in form, the material sifted and relaid, with the addition of as much new stone as may be required to make up the 2 in. The time of year most suitable for repairing roads is the spring; the succeeding summer then hardens the road and leaves it in a good condition to resist the traffic during the wet winter months.

Of the new asphalt roadway, the English experience is not yet sufficient to enable us to judge of its durability; but so far as it has gone the wear appears to be absolutely nothing in Threadneedle street and Cheapside, and the smoothness and noiselessness are much in its favor; but although it may ultimately be generally used, stone paving will probably continue in use for many years for the heaviest traffic, although the objections to it, even to the best kinds of stone, are numerous, and some kinds of stone are simply abominable from their slipperiness; and the noise that a stone-paved road produces is such that where the residents have sufficient influence over the parish or other local authorities, they prevent it being laid down, and in other instances, where the appeals against it have been unsuccessful, residents have vacated their houses, and the authorities have lost the rates upon the property. The only thing that can be said for stone paving is that it costs less in maintenance than a macadamized road does, where the traffic is excessively heavy; but when we come to get broken stone properly rolled and set before the traffic is turned on to it, there will be some hope of the more extensive use of that kind of road.

THE MINERAL WEALTH LOST TO FRANCE.

From "The Mining Journal."

Commissaries have been charged by Germany with the task of definitively adjusting at Brussels the conditions of the treaty of peace between France and Germany, and the German officials comprise a gentleman associated with mines. It is inferred from this circumstance that Germany is aiming at an industrial preponderance in Europe as well as at a consolidation of its military power. This policy will, probably, be attended with important consequences, not only for France and Germany, but also indirectly for Belgium and England. In consequence of the mineral wealth of the departments in the east of France, the French iron trade gradually acquired considerably increased importance during the 15 years ending with 1870 inclusive, although since last July it has, of course, been greatly depressed by the course of public events. In 1850 the total production of pig in the French furnaces amounted to 500,000 tons, of which about half was made with charcoal. The production had risen, however, in 1867, to 1,222,363 tons, and in 1868 to 1,274,333 tons, less than one-fifth being made with charcoal. Exact returns for 1869 and 1870 have not yet been made up by the French Government, but the production for 1869 has been estimated by the French Committee of Forgemasters at 1,380,000 tons, so that the production of pig in France would seem to have nearly

doubled within the last 20 years. In 1867, out of the whole total of 1,222,363 tons of pig made, the department of the Moselle produced 281,045 tons, or about one-fourth of the whole, and it is probable—although precise statistics on the subject make default—that considerable further progress was made in the Moselle during 1868 and 1869, as of all the French metallurgical groups it has generally displayed the greatest activity.

It is upon this fine district that Germany has this year laid its hands, in consequence of the collapse of the military power of France before the terrible legions of Prince Bismarck and Count Von Moltke. Through the new delimitation of her frontiers the Longwy basin has alone remained to France; and taking the statistics of 1867 as our guide, it would seem that the delimitation will be attended with the following results:

Work remaining in France.

Establishment.	Furnaces.	Production. Tons.
Gorcy	3	5,457
Mont St. Martin	2	19,425
Longwy Bas	2	8,542
Le Prieuré	2	15,447
Moulaine	2	10,905
Senelle	1	4,200
Rehon	2	12,490
Total	12	76,466

The following will be transferred to Germany:—

Works in Alsace and Loraine.

Establishment.	Furnaces.	Production. Tons.
Styring-Wendel	3	45,943
Hayange	5	50,563
Moyeuvre	3	37,044
St. Paul. St. Benoit Ars	4	27,540
Ars-sur-Moselle	1	9,070
Ottange	3	13,928
St. Claire	1	2,389
Mauterhausen	1	2,445
Novéaut	1	12,324
Villerupt	2	2,233
Audun-le-Tiche	1	1,100
Total	25	204,579

Three-fourths of the production of the old department of the Moselle will thus be diverted into the Zollverein, and the works ceded from the power of their capital, the force of their tools, and the extreme richness of the mineral bearings conceded to them, represent more than the proportionate share which they sustained in the total production.

It would appear that the Prussian plenipotentiaries have traced out the new frontier, not on any topographical plan, but very probably on a geological map prepared at Berlin. It is noticeable, for instance, that the new limits between France and Germany absorb, to the profit of the Germanic Confederation, all the rich bearings of oolitic ironstone in the Moselle and the Meurthe, the Longwy group excepted. Thus the concessions remaining in France comprise an area of 5,336 acres, producing, according to the last available return, 140,281 tons per annum, while the concessions in Alsace and Lorraine tranferred to Germany comprise an area of 18,062 acres, with a production of 500,660 tons per annum. The "Moniteur des Interets Materiels" considers that the relative production of pig in various European countries will be rather profoundly modified by these changes, and compares as follows the production of pig in 1866 with the estimated production of 1872:

Country.	Production, 1866. Tons.	Production. 1872. Tons.
Great Britain	4,592,000	5,100,000
France	1,253,000	1,062,000
Zollverein	1,079,000	1,907,000
Belgium	421,000	526,000
Austria	292,000	365,000
Sweden	256,000	293,000
Russia	350,000	420,000
Other countries	90,000	100,000
Total	8,313,000	9,773,000

The proportion sustained by Great Britain in the total production will, according to this estimate—which, after all, is rather curious than reliable—thus fall from 55 per cent. in 1866 to 52 per cent. in 1872. That of France will also fall from 15 to 11 per cent., but that of the Zollverein will advance from 13 to 19 per cent.

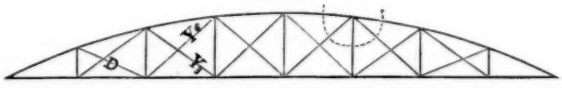
TITANIC ORE.—At the last meeting of the metal and coal trades at Swansea, a sample of titanic ore was exhibited containing a very large percentage of titanium. The price of the ore was 25s. per ton exship in the Bristol Channel. An analysis of this ore yielded the annexed results: Iron, 40.88 per cent.; oxygen, 20.57 per cent.; titanic acid, 31.72 per cent.; silica, 3.17 per cent.; lime, 0.97 per cent.; magnesia, 1.00 per cent., etc.

THE State with the greatest railroad mileage is Illinois, which has 7,186 miles.

CALCULATIONS OF STRAINS IN TRUSSES.—NO. III.

A reference to the calculations in the last article shows that the method applies to the diagonal and vertical members of a truss, because these take the greatest strain when the girder is partially loaded. To determine the law of dependence of strains upon the distribution of the load, it is only necessary to consider the general equations of moments, and to represent by diagram the girder in the condition corresponding to the omission of positive or negative members. It is thus

FIG. 1.



seen that any diagonal as Y_3 in the third bay receives a maximum tension if all apices at the right are loaded; and a maximum compression if all points at the left are loaded. If, in the same bay, instead of a diagonal sloping to the left, one sloping to the right be substituted, the reverse would be the case. For, if the girder is viewed from behind, the diagonal Y_6 appears in a corresponding position, and the equations of moments would also correspond.

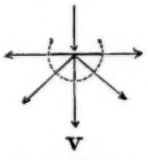
If both diagonals appear, and are constructed as ties or tension-members, not capable of compression, each is brought into action only by a distribution of load that causes tension, while the other is in the condition of a cord just stretched without strain. In this case only the maximum valves of Y enter; *e. g.*, in the third bay, for the diagonal Y_3 (max.) and for the diagonal Y_6 (max.). In a similar manner the strains of all diagonals can be found.

For vertical members of such a girder only the minima of the valves for V are taken into account, because tension cannot occur in them, if each of the diagonals meeting at a vertical is incapable of receiving compression.

A glance at Fig. 2 shows that this is impossible, otherwise the vertical force V would be taken up by no opposing force. That these minima apply to a girder with intersecting or crossing diagonals appears from the consideration that for a load on one side, only one of the two systems of diagonals is strained, so that the other need not be taken into account.

Hence with the results obtained, as in the last article, the magnitudes of the greatest tensions may be written on the corresponding diagonals.

FIG. 2.



If the diagonal members are constructed so as to receive compressions, as in the case of wooden trusses, an entirely similar process is adequate to obtain the desired results; but only the minima for diagonals and the maxima for verticals remain the same. As to the minima, it is plain that if the diagonals cannot convey tension, the direct load is the only one that can cause compression in the verticals. This varies (in the case of the last article modified for this occasion) between 1,000 and 1,000 + 5,000; hence

$$V\ (\text{min.}) = -6{,}000\ \text{k.}$$

The strains from left to right are as follows (for loads as in last article, for truss with intersecting or isosceles diagonals) :

	Bay 1.	2.	3.	4.	5.
Upper chord	— 48,000	— 48,000	— 48,000	— 48,000	— 48,000
Lower chord	+ 52,500	+ 50,300	+ 48,900	+ 48,100	+ 48,000
Verticals	— 6,000	— 6,000	— 6,000	— 6,000	— 6,000
Diagonals sloping to right	..	— 6,250	— 6,850	— 7,080	— 6,850
Diagonals sloping to left	..	— 5,470	— 6,250	— 6,850	— 7,080

In case of diagonals sloping only from the centre towards the abutments, the tension depends exclusively upon that of the chord segments intersecting at the foot of each. These are always subject to tension and therefore can only cause compression in the verticals. This is a maximum for a full load.

If the diagonals slope only from the abutment towards the centre, the direct load alone causes a strain in the vertical members.

IRON ABUTMENTS.

From "The Engineer."

Although there are abundance of instances in which iron, both cast and wrought, is the material used for the piers or intermediate supports of bridges, the examples are comparatively rare in which it is also employed for the terminal supports or abutments. It might appear, at first sight, that if the nature of the foundations rendered it advisable to adopt iron in the piers, the same conditions would dictate the use of iron in the abutments. But there are many reasons which demonstrate that this view is not necessarily correct or conclusive. In the first place, the character of the substratum in a tolerably wide river, often differs at different parts of the transverse section, and it is seldom that both abutments are founded at exactly the same level. There is a notable difference in the nature of the ground on the Surrey and Middlesex shores of the Thames, for example, and a dam that would fully answer its purpose on the one might not always be sufficiently strong on the other. This fact was well shown during the construction of that portion of the Northern Embankment near Blackfriars Bridge. Our readers will probably remember that a serious "blow" occurred in the dam, and yet this dam was almost identically similar in design to that which did its duty so well during the building of the river wall from Westminster to Vauxhall on the Surrey side of the Thames. On geological grounds, therefore, alone, brickwork or masonry might be well adapted for the abutments of a bridge, and yet be superseded by iron, with advantage, in the more central and deeper parts of the stream. It is not, however, until we come to regard the different duties a pier and an abutment have to perform, which necessitate a diversity in constructive detail, that the real reason of the general unsuitability of iron for abutments becomes manifest. The sole duty that a pier has to perform, so far as relates to the actual bridge itself, is to bear the direct vertical pressure of so much of the superstructure as falls to its share. There are no doubt in many instances other forces in operation which try its stability and strength, such as the velocity of a marine or river current, the impact of ice, or the concussions of floating bodies, but these are beside our subject. It is otherwise with an abutment. In addition to bearing its own share of the direct weight of the superstructure, it has to act as a retaining wall. It will be understood that at present we are speaking of those forms of bridges which exert no thrust against either the piers or abutments. As every bridge must have an approach to it, which is most frequently of earth, it is the necessity of making the abutment support this, that gives masonry or brickwork a decided superiority over both cast and wrought iron. Neglecting the value of the limiting angle of friction of the material, the horizontal pressure against the abutment will be directly proportional to the sheer mass or weight to be resisted, and common sense would instruct us that in all similar cases weight is best resisted by weight and solidity.

So far we have only taken into consideration that portion of the end supports which may be termed the abutments proper, but this is seldom sufficient of itself to retain the whole cross section of the approach. The retaining wall, regarded as a whole, comprises not merely the central vertical part which carries the superstructure, but the side portions as well, which have no vertical load to support, and are known as the wings of the bridges. These may be either "straight back" that is, built in a line parallel to the direction of the bridge, or "splayed,"

that is, receding from the face of the abutment at any given angle. In the former instance the top of the wing wall is horizontal, and in the latter, which is the form under present notice, the height diminishes from a maximum at its junction with the abutment to a minimum at the newel, the slope being parallel to that of the embanked approach. It is in the wings that the chief difficulty of employing iron with economy would be met. In the abutment proper a certain degree of strength is required to carry the vertical load, and this amount can be simultaneously utilized as a contribution to the total necessary for the retaining wall. On the other hand, the wings act simply as retaining walls, having no vertical weight to bear, and the question becomes reduced to one involving the relative economy of iron and masonry or brickwork. Without desiring for a moment to place a limit to the skill and ingenuity of engineers, yet we hold that for certain purposes certain materials are more suitable than others, and that the substitution of the wrong for the right is only effected at a commensurate sacrifice on the score of economy. Except in examples such as armor plating, targets, and engineering works of a warlike character, the substitution of iron for the older materials used in construction, will generally be found to be nearly equivalent to the substitution of the hollow for the solid form. Take the earliest, the cast-iron flanged girder. It is nothing else in form than a beam with the material cut away about the centre. The same statement holds good for wrought-iron girders, and the hollow column is only the stone pillar with its core extracted. It is not difficult to understand that a given amount of metal which would be able to support a given vertical weight would be quite inadequate to resist the same weight acting in a horizontal direction, or at an angle with the horizon. In the one case, supposing that there was no bending moment induced, the iron would only yield to a weight equal to its crushing pressure; in the other the resistance it would give would depend upon the direction of the strain it was subjected to. Iron wing walls must evidently consist of plates which, *per se*, have little or no stability, and this feature can only be imparted to them by the addition of stays and bracing. Some years ago we expressed our views on this very subject, and shall not recapitulate them, though we may observe that we have since seen no reason to alter our opinions.

Our attention has been again drawn to this question by a paper lately read before the Institution of Civil Engineers, "On the New Ross Bridge." In this case the abutments and wing walls consisted of cast-iron cylinders with cast-iron plates fitting in between them, and a strong backing of concrete, which is tantamount to so much solid masonry. The design of the cylinders and plates is precisely analogous to that constituting the foundations of the piers of Westminster Bridge, if we substitute piles for cylinders, and is nothing else than a cast-iron frame and panelling. The relative economy of this method of construction depends wholly upon the difficulties that may result from the presence of water. To build a retaining wall on dry land of cast-iron framing and panelling, to support a 25-ft. embankment, would be simply a great and unjustifiable waste of money; but to employ the same design in 25 ft. depth of water is another matter altogether. As a rule, it is certainly more expeditious to sink cylinders under water, and drive down panel plates between them, than to construct a temporary dam and build a solid wall of masonry and brickwork behind it. But it is not always so. If it can be satisfactorily established before the commencement of the work, that, from the nature of the substratum, there will be no trouble with the water, it is more than probable that the temporary dam and the solid wall would come quite as cheap as the cylinders and panelling. It is true that the latter plan dispenses with the temporary dam, but the sinking of the cylinders is not all plain sailing. It must also be borne in mind that, wherever cylinders are easily got down, it is equally easy to drive timber piles and construct a dam. Omitting the contingent difficulties in dealing with water, the actual cost of the two systems will differ to some extent, and the balance will be in favor of the solid wall. In the first place, the diameter of the cylinders will exceed the mean thickness of the solid wall, and the cement, concrete, or brickwork, with which they are filled, would materially contribute towards its construction. Calcula-

ting the cost of cast-iron panelling per sq. ft., and that of brickwork upon an average thickness in each case, the latter will have a slight balance in its favor. An instance recently came under our observation in which there is no doubt the employment of cast-iron cylinders and plates would have been advantageous. The case was a very exceptional one. The bridge was absolutely *a fleur d'eau*, the span being 50 ft. and the limit of headway from the surface of the water to the top of the metalling being only 2 ft. 6 in. The approaches were, therefore, virtually nothing, and consequently no wing walls were required. It was merely the question of the relative expense of sinking the cylinders and constructing the temporary dam. Apart from these considerations, there are one or two others which must not be disregarded when reviewing the whole subject. It is with pleasure that we are enabled to state that there has at last sprung up some desire among engineers to render their works more prepossessing in appearance than formerly. We will not go so far as to assert that they aspire to real æsthetical excellence on this point, but even this end may be ultimately attained. Sufficient progress has at any rate been made to warrant the statement that some regard must be had to appearance in all future designs. It is difficult to perceive how cast-iron framing and panelling would compete with masonry in this particular, without the incurring of expense that would be practically putting a veto upon the design. Genuine ornamental cast-iron work is of a very costly character. We have known as much as £140 per ton paid for it.

As a last consideration, that of durability must not be passed over. There are so many different opinions respecting the behavior of cast and wrought iron when exposed for some time to the action of either salt or fresh water, that no positive conclusion can be arrived at on the matter. Cast iron that has been exposed to sea water has been found so soft that it could be cut with a knife ; and, on the other hand, it has stood comparatively uninjured for years, in almost exactly similar situations. If we are not in a position to state the probable period that iron will remain in a sound condition under the circumstances alluded to, we can at least safely predict that good masonry or brickwork will in any case last as long as iron. The existence of the ancient Roman sewers and walls is a proof that there is, or perhaps, rather, was, a description of brickwork which may be pronounced practically indestructible. At the present day we may not quite come up to this standard of work, but it is possible we may go very near to it. It is alleged in favor of ironwork, that when it does rust the very rust itself acts as a protection against the further action of the cause that produced it. This may to some extent be true, but it must not be forgotten that rust never quite protected iron yet, and the argument is of small value. The durability of cast iron in the position under notice will be lessened if there is a tidal action at work, as the effect of alternate exposure to water and air is not confined solely to timber, but extends to metallic substances as well.

The Sherman Process, of which so much has been said and written in England during the past few months, appears to be losing favor. At the last meeting of the Iron and Steel Institute in London, such prominent iron-masters as Messrs. Menelaus of Dowlais, Hopkins of Cleveland, and Mr. I. L. Bell, stated that the results following his process were quite inappreciable. Mr. Siemens said that when he first heard of the process which claimed with an ounce of "physic" to drive out all the sulphur and phosphorus in a ton of iron, he knew such a result was impossible, and the experiments which had been made proved the correctness of his opinion.

Prof. G. Bischof, of Bonn, Prussia, is now in England with his apparatus for testing metals, which will have a place in the International Exhibition. The method of testing the quality of malleable metals and alloys consists in bending strips thereof alternately in contrary directions until they fracture, the number of times they are bent being duly recorded ; whereby a trustworthy and accurate indication is obtained of the quality of the metal relative to standard measurements previously ascertained.

ON THE IMPROVEMENT OF THE CHANNEL SERVICE BETWEEN FOLKESTONE AND BOULOGNE, AND THE VESSELS PROPOSED TO BE EMPLOYED.

By MICHAEL SCOTT, Esq, M. Inst. C. E.

From the "Journal of the Society of Arts."

On the present occasion the author proposes to confine his observations to the Folkestone and Boulogne route. It may reasonably be inferred that one effect of the recent disastrous war will be to postpone, perhaps for many years, the expenditure of large sums on local improvements in France. If so, it will be vain to expect that deep-water harbors should be constructed on the French coast, for the purpose of improving the communication with England. And it may be assumed that the formation of a deep-water harbor on the French coast would necessarily involve the construction of very costly fortifications for its defence; and, having regard to the present exigencies of the national exchequer, and to the financial condition which is likely to obtain for many a year, it does not seem probable that the French Government would care to undertake such works.

Beyond this, the author holds that, even were the money forthcoming, the period is still distant when the traffic could be expected to yield an adequate return on a large additional outlay.

On the threshold of the inquiry it will be necessary to discuss the necessity or otherwise of such service being at fixed hours, independent of tide or weather. For the mails, fixed hours are no doubt essential, but Folkestone and Boulogne are not the mail ports, and it has been affirmed that a comparatively minor expenditure would render the mail service quite regular between Dover and Calais.

For passengers, it might be said that, being independent of tide, the most convenient hours might be fixed and adhered to, whereas, with a tidal service, passengers have to leave London and Paris at different hours, and sometimes to arrive inconveniently late.

No doubt change of hour is essential; but it is not alone because the service is tidal that passengers have occasionally and necessarily to arrive late, but partly because of the length of time occupied in the journey; and therefore if, as it will hereafter be shown it is, it were practicable to reduce the time from London to Paris from 9½ hours to from 8½ to 8 hours, whilst the time for starting might not be altered, the latest time for arriving, and that only for a few days per month, would be about 10.30 P.M.

There is something also in the fact that, even assuming that an hour might be fixed which might prove most convenient for the majority of travellers, any one time would not necessarily be desirable for all. For example, to leave early in the morning might be most convenient for a business man, but it might not suit a delicate person or an invalid; and it is an advantage of the tidal system, that a choice of several different hours is offered.

As, however, so much has been said in commendation of fixity of service, especially as regards passenger traffic, let it be assumed that it would possess advantages, and let us proceed to consider what practical objections exist to the introduction of such a system. To go no further, it will be sufficient to advert to the want of the depth of water in the existing harbors, which precludes the possibility of a vessel sailing at or near a fixed hour. Hence the advocates of such a service state that, before their views can be carried out, well-sheltered harbors, with deep water, must be provided on both coasts, and thus a fixed service would involve great cost.

What is the value of fixity of service? Is it worth, and would it at present compensate for, an enormous additional expenditure of capital, not to mention augmented annual charges?

The author's proposals may be briefly summarized as follows:—

To provide for a tidal service between Folkestone and Boulogne, and taking care that the vessels, in size and cost of working, did not exceed the paying capacity of the trade, to quote Captain Tyler's recommendation, by "larger* ves-

* See that gentleman's valuable Report to Board of Trade.

sels with less movement in rough weather, more shelter, and better accommodation generally;" and, in order to effect this, to carry out certain improvements in the harbor of Folkestone, leaving the French authorities to do the needful at Boulogne, which will probably only include the works now being executed for increasing the backwater, and the arrangements for the landing and embarkation of passengers at the west side of the harbor. The author has not had an opportunity of minutely examining the harbor of Boulogne, but, judging from general knowledge of the port, his strong impression is that little or nothing more would be necessary.

Before proceeding to describe the vessels recommended as suitable, it is important to draw attention to the fact that storms are the exception, not the rule; and it seems only reasonable, whilst not ignoring the exceptions, that the arrangements made should have regard chiefly to the conditions which constitute the rule.

Captain Tyler says, in his report, that Captain Boxer, R.N., calculates that there are out of the 365 days, 29 days of gales and storms with heavy seas; 102 days of good round sea and breezes; 144 days with moderate weather and sea; and 90 days of calm weather. Adding to the 90 days of calm weather 144 days of moderate weather and sea, we have 234 days, or about two-thirds of the whole year, during which it may be affirmed that on board moderately large vessels no inconvenience would be felt from either rolling or pitching, and during an additional 102 days such vessels would have but little motion. There are thus left 29 days of gales and storms during which it may be assumed there would be considerable motion, even in the largest ship. But it should be observed—

1. That gales and storms occur principally during the winter, when the passengers are few, less than one-third of those travelling in summer; and therefore the number of days of bad weather is not a correct index of the number of persons who suffer from it.

2. Numbers of passengers avoid crossing in storms, and wait until they have blown over.

3. Any kind of vessel which could be employed would have motion in storms, and, if very large, there would be corresponding difficulty in handling them in the harbors, whilst the fares, from the small number of passengers crossing in the winter, would not meet the expense of running vessels of extraordinary dimensions, and, even if they possessed superior steadiness, it would not be required in summer.

Having now come to the vessels which it is proposed to employ, the chief requirements would appear to be—

1. That they should be steady, or have as little movement as possible in rough weather.

2. That they should be so large as to provide sufficient shelter, roomy, airy cabins, ample promenade space on deck, and every convenience for a large number of passengers.

3. That they should have high speed.

4. That they should have exceptional steering powers, and their machinery be extraordinarily handy, so that in the worst weather they might enter and leave the harbors with safety, be easily swung in narrow and confined spaces, and be able to avoid collision with other vessels in thick weather.

5. That, in addition to ordinary holds, the vessels should be constructed to carry on deck the vans loaded with passengers' luggage, and a number of goods-wagons, sufficient, so far as the more valuable kinds of goods are concerned, to accommodate the trade, and so transfer both luggage and merchandise (excluding very light and bulky articles) from one side to the other without breaking bulk.

Having explained his views as to what gives to a ship stability and steadiness at sea, which he does not consider as being synonymous terms, the author says:—

In the case under consideration, what we have to do is to give up sail, and diminish the amount of stability required, and then further to augment the steadiness by every reasonable means.

Much light has in recent years been thrown upon this question, and it is held that, *cæteris paribus*, we have a measure of the relative steadiness of vessels, in the position of the centre of gravity in relation to the metacentre; for it has been found that as these centres approach each other the stiffness decreases, but the steadiness increases, and *vice versa*. From this it follows that the nearer these centres

can be brought the better, if we want a remarkably steady ship; and this may be effected—first, by diminishing the breadth of the vessel; second, by increasing the displacement or draught of water; or third, by raising the weights of or in the vessel.

The effect of the opposite conditions is seen in ordinary steam vessels of light draught and high speed, which involves great weights of engines and boilers low down; hence such boats are unsteady and roll violently.

Lastly, on this point, as affecting rolling, it has been found advantageous to have the means of winging the weights.

In vessels for the channel service it obviously would not do to restrict their breadth, because this would be to diminish the space required for the comfortable accommodation of the passengers. Nor is it apparent at first sight how vessels with increased displacement and draught of water could make use of the existing harbors, or how their weights could be raised; but a brief outline description of the proposed steamers will show how steadiness may be secured in the manner indicated without involving what appears to be the corresponding disadvantages.

The author proposes that the vessels should be about 300 ft. in length between perpendiculars, and very little more over all, and about 36 ft. in breadth. The ordinary draught of water to be 8 ft. 6 in. with all weights on board, including passengers and their luggage and a considerable quantity of goods; and the vessels to be so constructed that, by the admission of water ballast when at sea in bad weather, they would be steadied by having their draught increased to 11 ft.

The vessels to be propelled by two pair of paddle-engines driving one pair of wheels amidships, and the speed to be 17 knots. Having two independent sets of propelling machinery, the vessels would require no masts, sails, or rigging.

It is further proposed that there should be three cabins for first-class passengers, viz., a main saloon, a ladies' saloon, and a cabin where refreshments could be obtained, and that there should be an after-cabin for second-class, and a fore-cabin for third-class passengers.

The first-class ladies' cabin would consist of a lofty saloon, before the machinery; further aft would be the main saloon, of large dimensions; and in connection with all the cabins there would be lavatories and other conveniences.

In addition to the unoccupied main deck fore and aft, and over the machinery, and to the wing passages along each side of the saloon cabins, there would be an extended promenade on the upper deck.

It is intended that the vessels should be constructed with double bottoms and double sides—in fact, except at the ends, the construction would be, to a great extent, like a hull within a hull; and, excepting where the steam machinery intervened, there would be a lower deck, all fore and aft, and water-tight athwartship bulkheads. The result would be great strength combined with lightness, and what is very important, security in the event of collision.

There are other reasons for adopting the construction described, which need not at present be adverted to; suffice it to say that the vessels would be almost unsinkable, a matter of some moment, considering that their course lies directly across the track of ships passing up and down the Channel. Spaces would be provided into which water ballast could be introduced, and thus the draught increased and the vessel steadied at sea in bad weather; and when nearing port the water could be expelled and the vessel raised to her light draught again. By simple arrangements, these operations, namely, the admission and expulsion of the water, could each be effected in less than five minutes. Such is a general outline of the dimensions and peculiarities of the proposed vessels.

Reverting now to the qualities which the vessels were to possess, it will be found that the first was steadiness in a sea-way. There being no masts or top hamper, and no sail to be carried, it is obvious that, as compared with rigged ships, the stiffness might be diminished with perfect safety.

The author does not ignore the fact that, the wind being favorable, sail steadies a vessel, but he wished to obtain a better result than sail would give; and it should be remembered that the full value of sail (for this purpose) could only be realized with the wind abeam or nearly so. Next, the form of hull might be such as, to a limited extent, to diminish the breadth at the water line without the displacement below; and by admitting water

into the compartments prepared for it, the draught would be increased, and the displacement still further augmented.

The same operation (the admission of water) could be so arranged as in some degree to regulate the position of the centre of gravity of the vessel in relation to the metacentre, and cause these to approach each other sufficiently near to produce steadiness combined with perfect safety. Moreover, the proposed arrangement would give the commander unexampled facilities for regulating the trim of his vessel, to suit varying conditions of loading and weather, and so to produce the best results.

Without going further into the subject, it will be apparent to all, that a large, well-proportioned ship would have less motion in our channel seas than a small light vessel, dancing on the surface; and therefore that, the steamers proposed being (in displacement) about four times as large as those at present employed, greatly increased steadiness and immunity from sickness on the part of passengers might safely be reckoned upon.

The next requirement was, that sufficient shelter and comfortable accommodation should be provided for a large number of passengers. A comparison with the steamers at present employed in the service between Folkestone and Boulogne will illustrate the superiority of the proposed vessels in this respect, for it would be found that the area of the deck and the area of cabin would be double that of the largest of the existing steamers.

The next requirement was that the vessels should have high speed. It will be enough to say that power sufficient has been reckoned upon to give a speed of 16 knots per hour, even in rough weather, so that, even in adverse circumstances, the passage could be made in about 95 min. The time at present allowed, including crossing the Channel, from starting at Charing-cross till the train leaves Boulogne, is about 5 hours 25 min., of which 3 hours and 10 min. is allowed from the time of leaving Folkestone harbor till the time of leaving Boulogne for Paris. On the return journey, the time from leaving Boulogne till the train leaves Folkestone for London is about 2 hours and 40 min. Then, as the proposed vessels would make the passage in 95 min., and with the improved arrangements contemplated at Folkestone, and the steamers being berthed close to the train on the west side of the harbor at Boulogne, 30 min. would be sufficient for embarkation and disembarkation, there would be a saving of from 50 min. to 1 hour and 20 min., thus reducing the journey to and from Paris to about 8¼ hours.

The fourth requirement was, that, as compared with the existing steamers, the new vessels should have superior steering and manœuvring powers. The recent opening of the new basin at Boulogne will no doubt do much to diminish the crowding of the tidal harbor, and the works being carried out are designed to improve the channel and entrance. Similarly the improvements which it is proposed should be effected at Folkestone would remove the existing difficulty to the entrance of vessels and their being swung in the harbor; but, nevertheless, chiefly with reference to Boulogne, it is suggested that the machinery of the proposed new vessels should be so arranged that, even in bad weather, they might be readily as well as safely handled.

When the International Communication Bill was before the Committee of the House of Commons, evidence was given, by eminent and experienced men, to prove that the increased size of vessels promotes steadiness in entering a harbor; and having had opportunities of discussing this matter with some gentlemen of experience, the conclusion the author arrived at was that such vessels as those proposed could be safely navigated to and from the port of Boulogne as it exists.

Although about 100 ft. between perpendiculars, they would only be about 70 ft. over all longer than the present steamers, and the increased length would render them less subject to be influenced by a heavy sea, whilst with disconnected paddles, and the starting gear now introduced, by which the engines are handled with such facility and rapidity, the course of the vessels would be more perfectly under control than if dependent upon the rudder alone; but as they could enter and leave the port at high speed, and consequently with good steerage-way, the influence of the rudder would also be augmented.

Inasmuch as the proposed vessels could

make the passage in less time than the steamers at present employed, a foot or more of tide might be saved when arriving on the ebb, and as the existing vessels draw 7 ft. 6 in. to 8 ft., the new steamers might have sufficient water although they drew 8 ft. 6 in.

But, to take the worst view of the matter, let it be assumed that there would arise occasions when the proposed vessels could not safely be taken into Boulogne harbor — what would this amount to? It has already been shown that out of the 365 days in the year, the average number of "days of gales and storms, with heavy seas," is only 29. Let it further be assumed that $\frac{2}{3}$ of these gales are from the westward, then the remaining $\frac{1}{3}$ would not preclude large vessels from entering or leaving, because Boulogne "is sheltered by Cape Grisnez from easterly gales." This would reduce the number to 20, and we arrive at the conclusion that, generally speaking, at a period of the year when the number of passengers is small, there would be a few occasions on which one of the existing packets would be substituted for the large vessel, and, it may be, one or two violent storms when no steamer could cross the Channel.

With disconnected wheels the vessels could be swung in harbor in little more than their own length, but, still further to facilitate their being handled, it is suggested that they should be fitted with steam capstans. Under this head it may also be desirable to mention that it is proposed that the saloon cabins should occupy the middle portion of the vessel. This is not unimportant, because a deck-house, for example, placed aft, would, from the action of the wind upon it in bad weather, render a vessel less manageable in entering a harbor.

The last requirement was that the vessels should be so constructed that the vans containing the passengers' luggage, and a certain number of wagons with merchandise, should be ferried across the Channel without being unloaded. The vans and wagons could be placed by a crane on the main deck, and secured there in a few minutes, but it is suggested with regard to the former that the bodies only should be shipped, and not the frames, wheels, and axles. They could be so constructed that there would be no difficulty in this.

Inasmuch as the weight of luggage and goods carried would vary, it seems to the author that the employment of water ballast would be advantageous, for otherwise the trim of the vessel would seldom be that which was desirable.

The Channel service is said not to be remunerative at present, and the question naturally arises, how will matters be improved in this respect by employing larger vessels?

There are now (between Folkestone and Boulogne) four services per day, viz., a morning or mid-day express boat from each side, and an evening or night boat from each side. This arrangement is no doubt necessary at present, on account of the smallness of the boats employed; but it does not appear that it would be necessary with larger vessels; and the author thinks it could be shown that one boat per day from each side would be quite sufficient for the traffic.

It is proposed that the vessels should be arranged to carry five goods wagons on deck, and, in addition, that they should have hold space for carrying a considerable quantity of merchandise below.

Then as to passengers. At certain seasons they are very numerous, but even during the busiest month, August, it would not be necessary to put on an extra steamer until the traffic had greatly increased; for it will be remembered that it has been shown that the proposed vessels would afford double the accommodation to be found in the largest of the existing steamers, and therefore there should be no doubt of their capacity and fitness to carry, at one trip, as many passengers as the present boats carry at two.

Nor does it appear that the existing double service is more convenient for passengers; for what are the facts? By the night service, the time occupied from London to Paris, and *vice versa*, varies from about 16 to 22 or 23 hours, the majority of the services averaging about 17 hours; and it is not conceivable that any one would subject themselves to the inconveniences of such a tedious journey unless for a weighty reason. This reason is doubtless to be found in the reduced charge; but if the fares be less, the

profit to the carriers must be diminished, and therefore it is not unreasonable to hold that the passenger traffic by the night boats does not pay. But is it not advantageous to the poor class? No doubt it is, and if these were very numerous at any period it might be desirable to run one of the existing small boats for their accommodation. At other times, a considerable number of third-class passengers might be carried by the express steamers at a slightly increased fare, compensation for which would be found in the saving of time and diminished cost of refreshment for the journey.

Assuming that there would always be sufficient accommodation in the mail steamers for the higher classes who prefer, or are compelled, to adopt night travelling, the author concludes that if the proposed vessels had only to make one passage for two of the existing steamers, it would follow that a great economy in working expenses would ensue—more than sufficient, one would think, to convert the alleged present loss into a considerable profit.

It is necessary to have special regard to the protection of the passengers from inclement weather when embarking or landing. This can be readily effected at Boulogne. In the case of Folkstone, the steamers are at times unable to enter the harbor; on such occasions the passengers are compelled to walk to or from the station to near the end of the western pier, exposed to rain and wind; but it is proposed that the embarkation and landing should always take place inside the improved harbor, and directly from the carriages, which would run alongside the steamers, so that the passengers would not at any time be exposed to the weather.

The new steamships would, of course, involve additional outlay; but considering that, one or two of the present vessels being retained, only two would be required, and that after they were built, the majority of the vessels composing the existing fleet might be disposed of, and that, being fast handy boats, they should realize good prices, it does not appear that a very serious addition would require to be made to the capital invested in shipping.

It will be seen that, according to the author's view, it would be better to postpone the establishment of a service at fixed hours until the traffic increased sufficiently to pay for it.

There is nothing startling in the present proposal. It may be said to consist chiefly in a somewhat novel combination of well-tried means to effect a specific result; for, to refer to one prominent feature of the plan, viz., the occasional use of water ballast, numerous vessels are daily at work which have their draught thus increased at pleasure, so as to bring them into good sailing trim. The peculiarity of the case under consideration is, the application of this system to secure the comfort of passengers at sea, and at the same time to overcome the difficulty arising from the deficiency of depth of water in the harbors.

Before concluding, one or two points remain to be noticed. It is obvious that such a system would not be applicable for long voyages; that when in rough weather the vessel was put down in the water to steady her, in order to maintain the same speed, additional power would have to be developed by the engines, and thus the consumption of fuel would be augmented. On examination, however, it will be found that the increased working charge for so short a distance is not worth consideration. During fine weather, of course, the vessel would be steady at her light draught, and therefore it would only be occasionally that she would be immersed to her deep line.

There would be a substantial increase in the first cost of the machinery, but, on the other hand, the engines could be worked more expansively, and therefore economically, when the vessel was at light draught.

It may occur to some that the varying immersion of the paddle wheels would be a difficulty, but it should be borne in mind that the diminished immersion of the floats at light draught would not be inconsistent with the decrease in power required to drive the vessel in that condition.

One word more. The quantity of water to be admitted and expelled for the purpose of bringing down the vessel from light to deep draught would necessarily be considerable; but it has been ascertained that 4 centrifugal pumps, and those not of extravagant dimensions, would suffice to effect the expulsion of the whole in less than 5 minutes.

ON THE FUSION OF WROUGHT OR FIBROUS IRON IN THE LARGE WAY IN REVERBERATORY FURNACES.

By JAMES D. WHELPLEY, M. D.

Certain experiments upon the fusion of wrought or fibrous iron in the large way in a reverberatory furnace were made at the experimental furnace works of Messrs. Whelpley & Storer, at South Boston, Mass., during the month of December, 1870.

It is well known that wrought or fibrous iron, made from pig iron by the common process of puddling or decarbonization, cannot be fused by the heat usually attained in reverberatory furnaces. It has been fused in crucibles or melting pots, such as are used for steel making, but not to my knowledge when laid uncovered upon the open hearth, or in large quantity, or without the assistance of a fusible carbonized iron as a flux.

By the elaborate experiments of Bessemer in England, it has been shown that the intensity of furnace heats can be raised to the melting of wrought iron by adding 20 lbs. to the sq. in. of common atmospheric pressure in a closed furnace constructed for the purpose.

For the perfect fusion and casting of large masses of fibrous iron it is necessary to create and sustain a temperature much above the original melting point. The bath of metal must retain the fluid condition during the process of casting.

A bar of fibrous iron heated to whiteness and exposed in a hot furnace to a blast of air directed upon its surface, burns and melts rapidly into black oxide or "cinder." It is not known what proportion of free oxygen in the mixed gases of a furnace, will cause the oxidation of fibrous iron; but it is certain that oxide of carbon, or hydrogen, must be present in excess to prevent it, and when steel containing only a fraction of 1 per cent. of carbon, or iron of a fibrous character containing only small quantities of carbon and silicon, are to be melted, the free oxygen present should be inappreciable.

In the furnaces constructed and used by Messrs. Whelpley & Storer, a cloud of finely pulverized bituminous coal is burned in the manner of a gas jet directly over the charge in the body of the furnace. The stream of pulverized fuel is projected horizontally through the furnace from the mouth-piece of a blow-pipe of 2 or 3 in. calibre. This blow-pipe jet supplying an impalpable dust of carbon, carrying less air than is needed for its complete combustion, passes first through a small gas flame furnished by an ordinary brick generator. A blast of hot air (500 deg. to 700 deg. Fahr.) is projected into the furnace through a separate pipe in conjunction with the jet of carbon. Combustion is completed in the body or oven of the furnace, which is constantly filled with fine floating carbon and gas in process of combustion. The pipes supplying fuel and hot air are governed by valves. The sole of the furnace is a long oval, 7 ft. by 5 in dimension, covered by an oven-shaped roof with uniform elliptic, hollow lines.

The first experiment made with this furnace gave a heat equal to that of an ordinary puddling furnace in one hour and a half from the time of lighting up. The hot air blast was then applied, and in another hour steel melted freely upon the hearth *without cover and without oxidation.* In four hours' time the heat of the furnace, using 160 lbs. per hour of extremely fine dust of bituminous coal, was such as to melt in 15 min. a charge of 60 lbs. of common merchant bar iron, laid cold upon the hearth. The effect of the furnace was then tried upon cold Bessemer rail ends, which were easily fused, 110 lbs. melting freely in 20 min. Common iron rail ends melted easily.

As it was now evident that the furnace would bear severer tests, a new hearth was made of the best quality of sand, suitable for steel melting.

After 5 hours of heating, the total consumption of fuel being 200 lbs. per hour, 600 lbs. of scrap boiler plate iron was charged in cold, and without cover. The entire charge came to a perfect fusion in 55 min. *without oxidation.**

Repetitions of the experiments, with larger and smaller charges, have constantly given similar results. The pro-

* In furnaces used for the manufacture of "mild" steel, or "homogeneous metal," the charge should be brought to a white heat before placing it in the furnace. The experiments above described were only made as tests of the heating power of the furnace.

cess of tempering the bath for steel of different grades is well known, and does not need to be described in this notice.

During the melting of fibrous iron there is certainly a free absorption, but probably not any decomposition of carbonic oxide by the metal at the time of fusion. Unless certain well-known precautions are taken the cast ingots are filled with bubbles of a non-oxidizing gas; but there is no evidence to show that any carbon from the gas enters into combination with the iron. I am inclined to believe that the fusion is favored by the free absorption of gaseous oxide (C O). The uncombined carbon, usually present in wrought iron in fractions of one per cent., probably takes the form of combined carbon during the fusion.

The experiments made in December were definite, and they are conclusive in regard to the fusion of wrought iron in quantity, without the addition of carbonizing materials, or covering to prevent oxidation. Scientific metallurgists will draw their own conclusions.

The metal produced by this cheap and simple method is of exceeding tenacity after condensation by hammering, and has all the characters of "mild" steel, or "homogeneous metal." It may be bent cold in large or small bars, and has, when cold, the qualities of the finest known brands of bar iron.

The temperature produced and sustained in so large a furnace, with so small a consumption of fuel, with the continued presence of a non-oxidizing flame, may be accounted for by supposing that the intensity of heat increases in some geometrical ratio of the quantity of carbon burned in a given time in a given space. Other explanations have been offered by scientists. Under all hypotheses, we know that the rapid and perfect combustion of solid carbon in particles microscopically small, should give higher temperatures than the combustion of gaseous carbon in any shape.

The highest working temperatures hitherto attained in reverberatory furnaces have been generated by the well-known process of Siemens now used in the manufacture of steel. The gases liberated by the slow combustion of bituminous coal in large generators furnished with a limited supply of air, are conducted and cooled in iron pipes which lead them into a reverberatory furnace, where they are turned in combination with a hot blast. It is not necessary to urge that the combustion of the cooled oxide of carbon thus produced, will not give an equal degree of heating effect with the combustion of an equivalent of solid carbon. The first equivalent of heat in the Siemens method is sacrificed in the production of gas. The second equivalent only can be utilized in the furnace. If the same quantity of carbon can be burned to carbonic acid in an equal or smaller space and in the same time, the first equivalent is utilized in conjunction with the second, giving of necessity a higher effective temperature. The hot blast is certainly indispensable, and in all well conducted establishments where there is a proper regard to economy, it will be produced by the utilization of waste heat.

In the furnaces constructed and used by Messrs. Whelpley & Storer, for the burning of pulverized carbon, carried by an air blast into the furnace, the intensities of heat generated by the blow-pipe flame, have been limited only by the fusibility of the brick work composing the sides and cover of the furnace. It is probable that in a small fire-box composed of less fusible material, let it be for example quick-lime, temperatures may be obtained by the burning of carbon dust in conjunction with a highly heated blast of atmospheric air or of oxygen which will fuse, not only platinum but the purer kinds of silicious minerals.

The mechanism for the pulverization of the coal employed in this process is to the general public and the engineering profession a very novel invention, although it has been in practical use in New England since 1863. A small iron drum or cylinder about 12 in. interior diameter and length, carries internally a steel axis furnished with paddles of soft steel, which move at the extremities of wrought iron arms without friction against the interior of the drum, at the rate of 10,000 per min. Small coal, bituminous slack, is fed automatically into the side of the drum about the shaft, and being reduced to dust by the violent rotatory action of the paddles, is drawn out by a small exhaust fan in a case of its own, which forms a part of the machine, and projected by the same through a 2 or 3 in. pipe of sheet iron into the furnace. The finely comminuted

fuel takes fire at the instant of entering the working chamber of the furnace. A force of 1-horse power is required for the comminution and delivery of 150 lbs. an hour of bituminous dust. The gas generator will consume at the same time about 50 lbs. an hour in anthracite slack. The hot hot-air blast is furnished by a set of cast-iron pipes in the stack. The generator and hot-air pipes are supplied with air from a small Sturtevant fan.

The fineness of pulverization is excessive, and can not be attained by any other known apparatus. It is apparently accomplished by the mutual attrition of the particles of coal, as there is no friction of iron surfaces or grinding action by the pulverizer. A cubic inch of coal presents 6 sq. in. of surface to the action of heat. The distillation of gas and combustion of the solid coke of bituminous coal in the lump is consequently slow, and subject for a long period of time to the causes of waste. After passing through the above-described air-mill of Messrs. Whelpley and Storer this same bulk of carbon will have its surface extended from 6 sq. in. to 40 sq. ft., and a considerable portion will have been so finely divided as to present 200 sq. ft. of surface to the cubic inch of solid.

Instantaneous and perfect combustion, with a proper supply of air, for carbon in this condition, is a matter of course, the gas and coke burning in swift succession. An expanding flame is produced of extreme and almost uniform intensity. Scrap-rail piles heated in this flame lose only 1½ or at most 2 per cent. of their weight. Pig-iron, puddled for bar, instead of losing, gains considerably in weight of metal through the reduction of metallic iron from the cinder and ore lining the furnace. The metal heated and worked under such a fire is free from particles of carbon and cinder, the generator sending over only a small volume of hot gases, and the entire body of ash passing with the draft into the ash-pit beyond the flue bridge. The texture of the rough or muck bar thus produced is uniform, whether made from scrap or pig metal, as there is no imperfection caused by unequal heating, oxidation, or ash.

I have forborne to enter upon details in this communication, as my purpose has been only to record the facts above stated. The use of carbon in fine dust mingled with a just proportion of atmospheric air has been long since regarded by scientific engineers as the theoretically perfect method of combustion. The problem has been to construct and apply a mechanism by which it should be made practicable.

LIGHT BOILERS.

From "The Engineer."

One of the great mechanical wants of the age is an extremely light steam generator of great power. The nearest approach to such a thing in existence is the boiler of a steam fire-engine—such, for example, as those made by Messrs. Shand & Mason and Messrs. Merryweather. But steam fire-engine boilers, as hitherto constructed, are unsuitable for constant hard work continued without intermission for days or weeks. Why want of endurance is a necessary accompaniment of their construction we shall explain further on. It is probable that the most efficient steam generator ever constructed has weighed, without its contents, little less than 56 lbs. for every horse-power indicated which it could develop—that is to say, a boiler weighing 25 cwt. might probably drive an engine, using steam economically, up to 50 indicated horse-power. If such a boiler could be so constructed that it would be suitable for use at sea a great advantage would be gained. For numerous other purposes, extremely light boilers are wanted. The production of a boiler which would give 1 horse-power of steam for each 20 lbs. of its own weight would indeed totally revolutionize many branches of engineering. Is it impossible to produce such a boiler? We think it is not; and we propose to state here our reasons for thinking it is not, and to indicate the nature of the principles which must be observed in the attempt to produce extraordinarily light boilers which can be worked safely and efficiently for many days and weeks at a time.

And first, we must see on what the weight of a boiler depends. In all cases

this is determined by the extent of heating surface, the pressure at which the boiler is worked, and the way in which the strains to which the boiler is exposed are dealt with. In some cases, as in egg-end boilers, the external shell forms heating surface. In others, as locomotive boilers, the heating surface exists independently of the shell; in others, as the Cornish boiler, the heating surface is partly made up by the shell and partly by special surfaces — flues — introduced as such. In all these boilers the weight is determined by the area of heating surface and the thickness which it is necessary to impart to the metal to make it resist the bursting strains to which it is exposed. The heaviest form which heating surface can assume is that of a flat plate, because it must be stayed to enable it to resist pressure. The lightest form is that of a tube exposed to external pressure, and the next lightest is that of a tube exposed to internal pressure. Spheres would be stronger than tubes of similar diameter by 2 to 1, but spheres present certain practical difficulties which render them unsuitable for the generation of steam; we are, therefore, driven the moment we attempt to produce a very light boiler, to the use of tubes. But whatever form the boiler may assume, it is certain that under existing arrangements it is essential that about 2 sq. ft. of heating surface should be provided for every indicated horse-power of steam required. In other words, about 2 sq. ft. of heating surface will evaporate not more than 30 lbs. or 35 lbs. of water per hour, with any approach to economy. The external surface presented by a tube increases in the precise ratio of its diameter. Its power to withstand bursting or compressive strains diminishes in the same ratio. It follows as a consequence that of two tubes exposed to the same strains, and presenting one twice the area of heating surface of the other, the larger tube must weigh four times as much as the smaller, for the area of metal in the large tube is twice as great as that in the small tube, and it is also twice as thick. It is, therefore, evident that the smaller we can keep our tubes the less will be the weight of a given area of heating surface, in about the ratio of the square of the diameter of the tubes. Consequently any extremely light steam generator must be mainly composed of very small and thin tubes. This is the principle adopted in the construction of the boilers of all steam fire-engines. There is a practical limit to the use of this principle which we shall consider in a moment. It may be taken as proved that it has been reached in the best modern steam fire-engine. If we want anything lighter still, or a boiler which, without being lighter, shall possess considerable powers of endurance, we must modify very largely the present system of working.

We have thus far seen that but one method of giving extreme lightness in a steam generator is available, namely, the reduction of the diameter and thickness of metal of the greater or lesser number of tubes of which such a boiler must of necessity be chiefly composed. We have now to consider another method of attaining the same end. This consists simply in augmenting the efficiency of heating surface. If we can make 1 sq. ft. of heating surface do the work of 2, then we can reduce the weight of our boiler by, roundly speaking, one-half; not quite half, perhaps, because the weight of the external shell affording steam and water space will be, to a limited extent, independent of the weight of the heating surface. It is in this direction, and in this direction alone, that we can find any prospect of making boilers lighter than the lightest now in use.

The practice of modern engineers tends to the development of very moderate degrees of heat in large furnaces and the extension of heating surface. In designing a very light boiler we must perforce adopt a totally opposite system. We must use a very intense heat, and reduce the surface intended to absorb it. Engineers adopt extended surface simply because it has hitherto been found essential to durability. Its absence in steam fire-engines explains that want of endurance alluded to at the commencement of this article; but we think it may be shown that, after all, extension of surface is but one way of obtaining the desired end, and that not the most efficient under any circumstances. If a portion of heating surface, such as a fire-box crown sheet, or a tube, is exposed to a very intense heat, it is rapidly burned, loses its "nature," and becomes brittle and rotten. But why? Simply because the temperature of the metal has been permitted to

become too high. In locomotive practice it has been found that some fire-boxes rapidly wear down to a thickness of about ¼ in., but beyond that point the waste becomes almost imperceptible, and American engineers, acting on this fact, often start with plates very little over ¼ in. thick, very closely stayed. It admits, we think, of proof that if any portion of heating surface can be kept so thin that the temperatures of the outside and of the inside of the metal are nearly identical, and little in excess of that of the water with which one surface ought to be in contact, no burning or wasting of the metal will take place. But this condition cannot be fulfilled in ordinary steam boilers. In such a generator as that used by Messrs. Shand and Mason, for example, we have small and thin tubes exposed to a very intense heat, which is as it should be ; but, on the other hand, the quantity of water contained in the boiler is so small, and the generation of steam so rapid, that it is certain the tubes can contain nothing but a species of froth. Steam and water cannot be in the same place at the same time, but the instant water reaches the tubes it becomes steam and repulses water ; and it is by no means impossible that under the conditions the relative time of contact of steam and of solid water with any portion of the tubes is measured approximately by their relative volumes. Instead of entering solid water, the heat passes from the furnace through the tube walls to a mixture of steam and water infinitely less efficient in keeping the metal cool than water alone. The remedy for this consists, not in reducing the temperature of the furnace, but in not permitting any steam to be generated in the tubes, which would then be filled with water only.

In the next place, it is by no means certain that heat is communicated to the heating surface of the best boiler in existence in the best possible way. If, instead of the products of combustion being allowed to flow rapidly *along* the surface to be heated, they were concentrated and compelled to impinge forcibly on that surface, their efficiency would, we have every reason to think, be promoted. The heat given out by the side of a gas jet, for example, is as nothing compared to heat imparted by the point of the jet violently impinging on a surface. This fact is well understood by engineers, and great care is taken in most instances to obviate impingement as effectually as possible. But impingement is only objectionable because the plates of the boiler are thick, and the water can be easily driven away from them. If the plates were very thin, and the water in close contact, impingement could do no harm.

Putting all this reasoning together, we arrive at the conclusion that an extremely light and efficient steam generator can be made in somewhat the following way. The heating surface must consist of tubes of very thin rolled copper not more than ¼ in. in diameter. These tubes will be so disposed as to connect 2 water chambers, both of which, with the tubes, must be kept quite full of water. With one of them will be connected a receiver and separator, into which a regulated quantity of water will flow constantly from the generating tubes. The formation of steam in the tubes must be prevented as completely as possible, and to this end the pressure in the tubes must be much higher than that in the receiver and separator. A pump must be provided by which the water will be kept in constant and very rapid motion through the tubes. Its work will consist in overcoming the frictional resistance of the water; but it is essential that the velocity of the water must be so great that any, even the smallest bubble of steam, or any even the smallest quantity of deposit, may be instantly swept off the metal, which must under all circumstances be constantly kept in the closest possible contact with solid water.

The arrangement of the tubes should be such that they may be exposed to the direct impact of a current of ignited gas generated in a suitable furnace and forcibly driven through the narrow spaces intervening between the tubes by a powerful blast. The heated water discharged into the separator or receiver will of course in part flash into steam for the supply of the engine, and in part be returned, to be again propelled through the tubes in a way which we described more particularly in an article which will be found at page 414 of our last volume. In the absence of direct experiment it is impossible to say how much steam can be generated in the hour by a single foot of heating surface ; but if we bear in mind that the metal would be extremely thin,

and in close contact—due to the action of the blast—on one side with a body of flame heated to at least 2,000 deg., while on the other, it would be in still closer contact with a hurrying body of water heated at most to about 300 deg., it will, we think, be freely admitted that, whatever its faults may be, such a generator would far transcend in efficiency, weight for weight, anything now in use; nor does it appear that any difficulties would be encountered in the construction of such a generator which could not be overcome by modern engineering skill.

THE SIEMENS REGENERATIVE FURNACE.

From the "Bulletin of the American Iron and Steel Association."

At the last meeting of the Cleveland Institute of Engineers, held at Middlesbrough, a paper on the above subject was contributed by Mr. Healey of Glasgow, in which he states that as he had had charge of the erection of these furnaces at a number of works in England and Scotland, during a period of six years, he trusted that the knowledge he had acquired of the theory of the system, and also its practical application, would make the paper useful and interesting. He considered that it would be tedious to go into the details of his experience generally, so he had selected the Blochairn Iron Works, Glasgow, as the basis of his paper. The author states that the application of the principle at the Blochairn Works is the most extensive in Great Britain, and, therefore, the facilities afforded for ascertaining practical results are very great, and such results may be set down as reliable in every respect. There are at present in the new works, 16 heating furnaces, and 24 double puddling furnaces; and 35 puddling, and 4 heating furnaces are to be built in the old works, part of which are now in course of erection, making a total of 20 heating furnaces, and 59 double puddling furnaces. The gas is applied at present to the new works from 48 producers, and a second arrangement is more than half built for the old works, which, when completed, will be connected to the first, making a total of 96 producers. The gas producers may be constructed of various forms to suit the fuel to be used, which may consist of any carbonaceous substance; coal being the fuel chiefly used in England and America, wood in France and Spain, peat in Italy, sawdust in Sweden, and lignite in various parts of Germany. The coals are delivered by canal at one end of the producers, and wheeled from the quay to the several coal bunkers. Mr. Healey mentions that small coal or slack, well washed, makes better gas than round coal, but in working with the former it is necessary to keep the fuel on the grate much thinner than with the latter.

It is important that a continuous pressure be maintained in the producers and flues to prevent any indraught of air. Where the producers can be built on a much lower level than the furnaces, this is at once obtained; but generally the furnaces and producers stand on about the same level, and in such cases the best plan is to elevate the cooling tubes, as by this means a siphon is formed, in which the limbs are of equal length, but one is charged with heavier gas than the other. This pressure is sometimes obtained by using jets of steam under the producer grate. At Blochairn the top of the producers is 3 ft. below the mill floor, and consequently there is always a good pressure throughout. It had been argued that this siphon action wastes a certain amount of heat, but this is not the case, as the temperature of the gas entering the chambers regulates to a great extent the temperature of the waste gases passing off to the chimney flue; the cooling tubes, on the other hand, have the advantage of condensing the vapor that may be carried off from wet fuel, which would otherwise oxidize the metal in the furnace. The heat from the cooling tubes will be economized for heating the water for the boilers, by making each of the horizontal tubes with an outer belt, four feet wide, near to the upcasts, between which and the tubes the water may circulate. The heat at the upcast end of the tubes is about 1,100 deg., and the application of this plan will insure a considerable saving of fuel at the boilers. The producers are generally arranged in

groups of four, the gas from each group leading into one of the upcasts. At these works three such groups are built together, forming one wing of a division, the cooling tubes from which are attached to the left side of a main collecting tube, while three similar tubes collecting the gas from another wing, are fixed on the right side, and the gas from six groups is thus conveyed through the main tube across the canal, a distance of about 176 ft., to the downcast, which, in its turn, is connected to the main gas flues leading off the furnaces. The gas produced in the manner described is the fuel used in the furnaces. The furnace is constructed, as its name implies, with regenerators, which consist of four chambers built in pairs under the furnace, one of each pair being for gas, and the other for air. These chambers are built with fire-bricks, spaced so as as to allow sufficient flue room, and the courses are set so that the bricks of one course of regenerators cover the spaces of the next, thus causing the currents to impinge freely upon the bricks, by which means a large surface is exposed for taking up the waste heat of the furnace.

The regenerators vary in size according to the work to be done, but taking the products of combustion of 1 lb. of coal as possessing a capacity for heat equal to that of 17 lbs. of fire-brick, that quantity of regenerators in each pair of chambers would be sufficient theoretically for each pound of coal converted into gas; but about four times as much regenerative power is practically required, as only about one-fourth of the regenerators are heated to the full temperature of the heat passing down the ports. The best size and arrangement of bricks for the regenerators has been determined by a series of experiments; but no definite rule can be given, as various circumstances have to be taken into account in designing a furnace, such as temperature, degree of steadiness required, and period between reversals, every application requiring special combinations to adapt the principle. The gas flame being purer than the flame in an ordinary furnace, does not cut the brickwork; hence, if the best material be used for the upper parts of the furnace, the repairs are very light. When it is considered that a mass of metal has to be heated to a temperature of 2,000 deg. by a flame of, say 3,000 deg., it is evident that the waste heat will be about 2,000 deg., most of which is economized in the regenerative furnace. The means at command for regulating the flame is in itself a great advantage, as at any moment the flame may be changed to suit any requirement, and may be of any length, and either reducing or oxidizing. At Blochairn the nearest furnaces are at a distance of about 300 ft. from the gas producers, which allows the operations in the works to be carried on with much greater cleanliness than usual. Many persons have been misinformed as to the cost of these furnaces, and for the guidance of such, he remarks that at the new works referred to, where they have been erected in preference to all others, and are capable of producing about 2,000 tons of iron, in the shape of plates, angles, bars, and rails, weekly, the cost, without royalty, has been no more than would have been the case if the old kind of furnaces had been laid down, partly owing to the great saving of room; the space usually occupied by coal bunkers and fire grates not being required under the main roof. In working these furnaces, the valves are reversed at regular intervals of about 30 min.; the regularity is of greater importance than the frequency of such reversals, for this reason, that if the hot waste gases impinge for a longer time on one side of the butterfly valves than on the other, they are liable to twist, and so will not bear truly on their seats in the reversing valves, and the regenerators are also heated unequally by the same cause, and in such a case the furnace works hotter at one end than the other, which however, is soon set right by care in reversing. The author states that a charge may be left in one of these furnaces an almost indefinite time without wasting to any great extent. Instances have occured under his own notice, of charges of about 5 tons being left in the furnace for 30 hours, and after being heated ready for the rolls, the heat has been let down, and got up again, when the rolls are ready for work; this process of getting up the heat, and letting it down, was repeated thrice on one occasion during a period of 30 hours, and the charge was afterwards rolled into iron of the best quality, the length of time during which it was exposed to the gas flame having had no perceivable detrimental effect upon it.

The heating power of these furnaces is about 12 tons of piles in 12 hours. The best material for the exposed parts of these furnaces is made from fire-clay, found at Glenboig and Gartcosh, near Glasgow, but any good fire-brick will answer for the lower parts. He then touches upon the subject of the application of Siemens' principle to puddling, and says that recent results obtained at Glasgow have proved that the advantages of the regenerative gas furnace for puddling are very important, and although many difficulties have presented themselves in the various details, they have been overcome. Comparing the results as to yield of Siemens' furnace, with results of an ordinary furnace, with, say 8 per cent. of waste, there is something very striking. In an ordinary furnace there is a great waste of iron, caused no doubt by the free oxygen present, which burns a part of the iron, and thus the increased temperature required at the time of balling the iron is obtained at the expense of this waste, and it is doubtful whether the heat required at this stage of the process could be obtained in an ordinary furnace without thus using a portion of the iron as fuel. When the iron is being puddled the heat is comparatively low, but when it comes to "nature" the heat requires to be increased speedily so as to completely weld the particles together. This change of temperature is obtained in the gas furnace in as little time as it would take me to describe it, and much time is saved in the manipulation of the valves over that required to obtain similar results in the old way. The work that can be done in a puddling furnace of this description is 5 charges of 10 cwt. each per day, besides scrap balls; and when working with plate metal and gray pig the men perform the work in about 10 hours, while with full charges of gray pig 10½ hours is required. The improved quality of iron produced in these furnaces is attributed to the greater purity of the flame, and also to the great heat at which the furnaces may be worked, as it is well known that when the iron has come fully to the boil, if the furnace is kept as hot as possible, the cinder is more liquid and less liable to be lapped in the balls when under the hammer. The ports of these furnaces should be built of silica bricks from the floor line to the top of the mixture, although Glenboig or Gartcosh bricks are found to stand very well for the crowns, jambs, and port ends of the regenerators. It has been practically proved that there is a considerable saving in the cost of fuel, as fuel of inferior quality can be used in the gas producers such as could not be used in an ordinary furnace; and the weight used being also much less, the actual saving may be safely put down as from 30 to 50 per cent., varying according to the work for which the furnace is adapted. The most important feature in economy is the fact that at least 50 per cent. of the usual waste of iron in the heating furnaces is saved, and that in puddling, the yield is generally equal to the weight of the metal charged. With regard to general convenience and facility of operation, he instances that some time ago Scotch workmen intimated that they would not work these furnaces; now, however, that such furnaces are actually at work, they prefer them, and on a late occasion, when a part only of the Blochairn furnaces were to be worked, they requested the gas furnaces to be lighted in preference to the old ones. Mr. Healey states that the heating furnaces which are now being built by the Britannia Iron Co., Middlesbrough, are somewhat similar to those at the Blochairn Iron Works, and as soon as they get fairly to work, he expects other firms in the district will perceive more clearly the numerous advantages to be derived from this application.

Professor Zollner has published the result of some experiments made upon the spectrum of the aurora borealis last October. The conclusion which he draws is, that if the light arises from incandescent gas particles of our atmosphere, the temperature at which it takes place must be very much lower than is required to render the same gases incandescent in Geiseler's tubes, so that the region in which the phenomenon occurs must be of extreme tenuity.

The Act of 1864 for the testing of chain cables and anchors, expires in 1872, and the Board of Trade have a bill in preparation, not merely to renew but likewise to amend some of the provisions of the Act.

BURNT IRON AND BURNT STEEL.*

By MR. MATTIEU WILLIAMS.

From "Ryland's Iron Trade Circular."

After quoting the attempts already made to explain the chemistry of "burnt" iron and "burnt" steel, Mr. Williams referred to the practical importance of obtaining some laboratory method of readily determining whether the brittleness or rottenness of a given sample of manufactured iron was due to original impurities of the raw material or to the fault of the workman who had burnt the iron in forging it. The conflicting and unsatisfactory theories of the chemistry of the changes effected in burning at first stood in the way of his attempts to solve this problem, when an accident revealed the true theory, and at the same time suggested the desired practical test.

Two samples of borings, marked "Steel A" and "Steel B," were sent to him to analyze, but he found that one of them contained no carbon and the other a mere trace; that consequently they were not steel, but both were iron. A difference in the behavior of the samples when the acid solvent (nitric acid diluted to the the specific gravity of one-half) was first applied was observed. Sample A rendered the acid dark-colored and turbid; sample B presented the usual appearance of good iron in the course of solution. The darkness or turbidity of A disappeared when the solution was complete, and no insoluble residue was left behind. Further examination proved that the peculiar appearances presented by A were due to the presence of minute particles of oxide of iron intermingled throughout the sample; and upon further inquiry it was ascertained that the marking of the samples as "steel" was merely a trick of an oversharp, excessively "practical" man, who thought the chemist could not distinguish borings or filings of steel from borings or filings of iron. Sample A was from one side of an armor plate which had been burnt, and B was from the opposite side of the same plate, but which had escaped the burning. Further experiments were made with samples of burnt iron of different degrees of rottenness, ranging from barely damaged specimens to the extreme case of burning presented by the contents of the Bessemer converter before the spiegeleisen is added. In all these, free oxide of iron was found not merely on the surface, but *diffused more or less completely throughout the substance of the iron.* It was further found that the simple test of adding borings of such iron to nitric acid of specific gravity one-half affords, after a little practice in recognizing the peculiar appearance presented by the suspended black particles that are suspended by the effervescence, a reliable and very ready and rapid method of detecting the burnt iron, as the silicon and graphite of cast-iron or pig-iron produce a turbidity and darkness which may be mistaken for the appearance due to oxide. The dark color produced by the combined carbon of steel is distinguishable by its permanency. Burnt steel was next examined. This presented no indications of the presence of free oxide, as was theoretically expected; previous observations and experiments having shown that the presence of combined carbon protects iron from oxidation by heat.

What, then, is the action of burning in the case of steel? Mr. Williams described a number of experiments wherein he subjected bars and plates of steel of known composition to the action of furnace heat, for periods varying from a few hours to four days, and found that in every case the quantity of carbon was diminished in proportion to the period and severity of the exposure; that this removal of carbon was not confined to the surface, but, in lesser degree, it occurred throughout the substance of the steel. When steel was burnt there was always a loss of carbon.

From these facts he inferred that the damage done to steel by burning is due to the oxidation of the carbon. It is well known to practical men that when steel is thus burnt, by raising it to a yellow or white heat, and then suddenly cooling it, the "grain" exhibited by fracture is much coarser than in another piece of the same bar which has only been moderately heated. This coarse grain is usually called

* Extracts from a Paper read before the London Chemical Society.

crystalline; but Mr. Williams controverted this idea of crystallization, as the facets of the grains, when examined with a hand magnifier, exhibit concave and convex faces, rather than the plane surfaces characteristic of crystallization. He suggested that the structure of burnt steel would be more correctly described as "spongy" than as crystalline, and he attributed this spongy structure to the evolution or suppressed occlusion of carbonic oxide, and possibly of oxygen also, which have been suddenly arrested in the passage through the metal, and thus existed as minute bubbles in the steel.

To those who are unacquainted with the researches of Deville, Troost, and Graham, this idea of oxygen penetrating the substance of solid bars of iron and steel, and oxidizing the iron or carbon of their interior, may appear rather startling; that the researches of the above-named philosophers have proved conclusively that gases pass through highly heated iron and steel with a facility which may be rudely compared to the passage of water through blotting paper; that certain gases become "occluded," or hidden, in wondrous quantities within these and other metals, and there retained in mysterious imprisonment, to be again set free under varying conditions of temperature and pressure. This being the case, the difficulty of conceiving the internal oxidation of iron and carbon, and the internal formation of carbonic oxide, is removed. When the steel is highly heated, and the oxidation of its carbon, and the consequent evolution of carbonic oxide is rapidly proceeding, it is easy to conceive that a sudden suppression of this action, by plunging the steel in water, may fix the gases in the act of passage; and, while still in the gaseous condition, this would produce the spongy state, and exhibit the concave faces of the minute air-bubble cavities.

The paper concluded with a promise of further communications to the Society on the subject of the so-called "crystalline" and "fibrous" structure of iron, the writer regarding the appearance and mechanical peculiarities usually ascribed to crystalline as the result of the occlusion, exclusion, endosmosis, and exosmosis of gases in the metal, and its consequent spongy structure; and the "fibrous structure of iron to the rolling down or consolidation of this spongy structure, and the welding up of its pores."

ON THE COMMERCIAL ECONOMY OF SEVERAL TYPES OF MERCHANT STEAMERS ON SOME OF THE PRINCIPAL LINES OF STEAMSHIP TRAFFIC.

By WALTER C. BERGIUS, Esq.

From the "Journal of the Society of Arts."

There has been such extraordinary progress made within the last few years in the powers of locomotion, and the commercial economy of steamships, that the economical conditions of the carrying trade at sea have been most materially changed, and are still changing in favor of improved and well-managed steam carriers *versus* sailing vessels.

For the purposes of comparison I give below a table showing the annual performance and the annual cost of 5 different merchant steamers, each representing, as to size, speed, and the local and economical conditions of its traffic, a distinct type of ship.

To compare these 5 types of ships upon fair and equal terms, I have omitted in their cost per annum the expenditure in port dues and pilotage, as well as the risks of interruption of traffic by accident which would not be covered by insurance. The management account, which is so extremely different in different undertakings, and has really little to do with the engineering question of commercial economy, has also been omitted—so that the three items constituting the annual cost of the vessels are only crew and provisions account, coal and engine store account, interest, depreciation, wear and tear, and assurance account; the latter figure being charged at an equal rate or percentage of value against all the ships except the "foreign coaster," which has to carry ½ more under this

head, as she trades in a locality where accidents to her machinery involve at once a voyage, perhaps under sail, to a repairing port not situated on her line.

The figures given for the annual performance of the 5 ships are likewise computed in such a manner as to bring them upon a fair and equal footing for comparison. As we wish to consider only the engineering question of commercial economy, we must assume the ships to be fully employed all through the year, omitting to take into account any loss of time resulting in one or other of them through ice in her ports of sailing, or through delays arising from extraordinary repairs which are not made good by the underwriters. We must further assume the 5 ships always to have full cargo, deducting, in computing the dead weight carriage, the amount of coal carried for the particular trade the vessels are engaged in, and fixing the draught and dryside in accordance with the scale of the Liverpool Association of Underwriters for the Protection of Shipping.

The performance of the 5 ships is given in carriage units, called "ton-miles," computed in an analogous sense to "train-mile" in railway terminology. A ton-mile is the performance accomplished in carrying one ton of dead weight for the distance of one nautical mile; therefore, if a ship carries 200 tons dead weight, besides her coal, upon load draught, and runs a distance of 35,000 nautical miles per annum, her total annual performance as a freight carrier is 35,000 × 200, equal to 7,000,000 ton-miles.

Annual Cost and Annual Commercial Performance of five Merchant Steamers recently constructed.

TYPE OF SHIP.	Annual cost of ships.				Annual commercial performance of ships.			
	Interest, tear and wear, maintenance, and insurance accounts.	Coal and engine store accounts.	Crew and provision accounts.	Total annual cost of ships.	Dead weight besides coal.	Mileage per year.	Commercial performance per year.	First cost of commercial performance.
	£	£.	£.	£.	Tons.	Naut'al Miles.	Ton-miles.	Pence per ton-mile of carriage.
1. German Ocean water ballast collier..	3,100	540	1,350	4,990	1,000	38,000	38 millions	0.031 *d.*
2. Baltic goods carrier.....	4,500	2,450	1,850	8,800	1,000	37,000	38 "	0.057 *d.*
3. Home trade grain carrier	1,500	520	1,250	3,270	350	38,000	13½ "	0 058 *d.*
4. Foreign coasting steamer.....	3,500	4,750	1,550	9,800	500	38,000	19 "	0.124 *d.*
5. North Atlantic mail steamer	18,000	8,400	1,300	34,700	1,200	42,000	50½ "	0.165 *d.*

A few general data about the economical conditions of the service of the 5 ships above mentioned should be added to the table.

1. The German Ocean water-ballast collier trades under the advantage of the cheap coal of a coal-exporting port, and carries, like the Baltic goods carrier and the home-trade grain carrier, its own coal for the home voyage on leaving the United Kingdom. The 38 millions ton-miles of commercial performance, which she can do at a cost of $4,990, are not realized in her service, as she makes her own trips in water ballast only, so that, in the present practice, one ton-mile of coal carriage costs 0.062d.

2. The Baltic goods carrier is proportionately very expensive in her coal account, as she has common engines and a common condenser also, although of recent construction. She goes at a speed of 10 knots in service.

3. The home trade grain carrier, on account of her small tonnage, is expensive in crew and provisions account, and has dearer fuel, as she trades from Channel ports.

4. The foreign coasting steamer pays £3 per ton for her coal, and, as she has

some 35 per cent. of her value charged against her annually, by way of interest, depreciation, tear and wear, and maintenance and insurance account, on account of the excessive cost of repairs in her service, her performance as a freight carrier is necessarily very expensive for so slow a vessel—her speed in service being only 9 knots.

5. The North Atlantic mail steamer is a very expensive freight carrier, both for the cost of her large crew and for her great first cost. Both these conditions, of course, are consequent upon the nature of her service, her extreme speed of some 13 knots in service necessitating such an immense consumption of fuel, which, with the length of the voyage, increases immensly the size and cost of the ship of comparatively small dead weight capacity. She uses Welsh coal on her voyage out, and American coal coming home, both of which qualities of fuel, of course, are much more expensive than the fuel used in home-trade ships.

The figures given above as the cost of one ton-mile of freight carriage in different lines of steamship traffic, differ very much in amount, and will repay the trouble of some further consideration. The 13 knots North Atlantic mail steamer, having to carry all its coal for a voyage of some 3,000 nautical miles, and being therefore, comparatively to her size and cost, small in dead weight capacity, costs over five times the amount per ton-mile freight of carriage compared with the German Ocean collier doing the same unit of performance.

The principal items of commercial economy of merchant steamers, viz. : cost of coal per ton, speed per ton in service, length of voyage, appear graphically in the diagrams, each of which is intended to illustrate the influence of one of these items upon one of the steamers of our table.

The diagrams are computed in the ordinary manner, and will scarcely need any explanation for being read by the gentlemen present, many of whom have so largely assisted the introduction of the graphical system of investigation.

The object of the writer in compiling the above figures and diagrams was not so much to convey information concerning any novel or extraordinary facts, as an attempt to arrange and reduce to practice, from a commercial point of view, some general items of the present economical conditions under which goods are carried on some principal lines of steamship traffic.

Cold Galvanization of Iron.—The metal is first cleaned by being placed in a bath, made up of water, 1,000 litres ; hydrochloric acid, 550 litres ; sulphuric acid, 50 litres ; glycerine, 20 litres. On being removed from that bath, the metal is placed in a bath containing 10 per cent. of carbonate of potassa, and is next transferred to a metallizing bath, consisting of water, 1,000 litres ; chloride of tin, 5 kilogr. ; acid sulphate of alumina, 4 kilogr. ; chloride of alumina, 10 kilogr. The metal is left in this mixture for from 3 to 12 hours, according to the thickness of the layer of zinc to be desired.

Iron telegraph posts have been introduced with great success in Switzerland, and are now being extended daily. They have been already put up along the railways betwen Basle and Dudingen, Otten and Zurich, and St. Gallen and Rorsehach—a total distance of 350 miles. In Prussia they have been placed experimentally on the railway from Weissenfels to Gera, and on the line between Berlin and Potsdam. As iron is now so cheap, it is considered that in a short time they will altogether replace the old wooden poles in Germany, that cause so frequent interruptions to telegraphic communication from rotting or being blown down by every high wind, especially in exposed situations.

A Telegraph Company is being organized in San Francisco, for the purpose of laying a marine cable to the Sandwich Islands, Japan and China. Congress will be asked for a charter at its next session. It is claimed that this enterprise is favored by the governments of the countries to which it is to be extended.

Minnesota has 950 miles of completed railroads, and 1,130 miles projected and in course of construction.

THE MANUFACTURING INDUSTRY OF SCOTLAND.

(From "The Mining Journal."

We propose to lay before our readers a description of the Stobcross Rivet Works, which are about the largest and most complete of their kind in Glasgow, and where the operations carried on bear a close affinity to certain other departments of marine architecture. Although the Stobcross Rivet Works were established in 1840, it was not until some 22 years ago that they passed into the hands of Mr. James Miller, their present proprietor, who had previously superintended their operations as responsible manager. The works were originally built on a much smaller scale, and were altogether more restricted in their operations than at present. Although perfectly compact, the additions made from time to time to meet the exigencies of an extended business impart to the buildings a rather irregular appearance. The main entrance is from Stobcross street, at the western extremity of Glasgow, on the north bank of the Clyde. The buildings appear to form three sides of a square, but there is a large smithy behind, and other accommodation, entirely apart from the premises, which abut upon the front yard. There are 10 lever machines and 1 vertical used for making rivets, but other 2 of the former kind are in process of construction, so that within a short time there will be 13 different machines regularly at work. At present the average production of the works is at the rate of 230 tons of rivets alone per month, and about 200 hands are regularly employed. The rods from which the rivets are made are procured principally from Coatbridge and Workington. The vertical machine is the invention of Mr. Robt. Griffiths, of whom many of our readers will have heard in connection with his improvement of the screw propeller. We believe the vertical is admittedly superior to the lever machine in many respects, and chiefly on account of its increased power of production. It will turn out, on an average, something like 3 tons of rivets per day, or, in other words, about 60 rivets per minute, as compared with 30 rivets per minute from the lever. Hitherto, however, the vertical has been found difficult to manage. Its construction is of a complicated character; it is readily liable to go wrong, and once out of repair it is not so easy to put it to rights again. For some time past Mr. Miller has been endeavoring to simplify, and render more workable, the arrangements of the vertical, and in this he has been so far successful that when his experiments have been fully carried out he intends to introduce several of the modified machines into his works.

The process of manufacturing rivets is very simple and easy. The rods, which measure from 6 to 12 ft. in length, are first put into a heating-furnace, where they are brought to a welding heat. There are two of these furnaces on the works, and in each furnace there are 2 plates or doors, containing some 10 or 14 holes, just sufficiently large to admit the rods without difficulty. Through these holes the rods are introduced to the furnace, and heated without interfering with the comfort of the man or boy who attends to this part of the business. In other respects the furnaces are similar in appearance and construction to other air-furnaces of the best known kind. As the rods are sufficiently hot for the purposes of manipulation, they are taken in succession from the furnace to the rivet-making machine, where they are cut up into the required lengths by means of a small shears. After passing through this process, the lengths are picked up by another man, who wields a tongs in the one hand, and a hammer in the other. With the tongs the lengths are placed in dies, which correspond with the intended thickness of the rivets, and a good blow from the hammer which the workman wields in his other hand sends them home. There are 10 of these dies or holes for the shaping of the rivets in an ordinary lever machine, and they are placed at regular intervals on a circular iron block or table, which revolves slowly while the process is going on. The dies can be taken from the table at pleasure, and adapted to any size of rivet. In course of revolving, a snap or hammer in the centre of the machine comes down upon and gives shape to the head of the rivet, which is delivered by a tilt at the other side. The rivets usually vary from

¼ to 1¼ in. in diameter. So much for the lever machine. The vertical works in a somewhat similar manner, with this important difference, that it is self-feeding, and has 16 dies in the table instead of 10. In the furnaces a large proportion of char is used, and the waste heat is utilized to raise steam in the boilers immediately adjoining. The boilers are two in number, one being attached to each furnace, and are of the well-known Cornish two-flued description. There are two engines on the premises. One is a beam-engine of 45-horse power, 16 in. cylinder, and 3½ ft. stroke. The other is a vertical engine of 14-horse power, 12 in. cylinder, and 2½ ft. stroke. The heavier engine drives all the rivet-making machinery below, and a large fan, made and patented by Russell, of Motherwell, near Glasgow, while the other is used for a number of lathes and other smaller appliances upstairs, as well as to pump water. The whole of the machinery, the engines excepted, has been made on the premises. On the east side of the yards there is a large store used for packing up the rivets in barrels when they are intended for exportation.

In the smiths' shop, which measures about 150 ft. by 40 ft., there are 12 hearths, at each of which 2 men are employed, and it is in this department that the bolts are chiefly manufactured. Russell's improved fan, to which allusion has already been made, supplies the blast for the whole of the fires, and is driven by 2 belts off the large engine. The rods for bolt making are similar to the rivet bolts, but the mode of manipulation and the appliances used are different. After being heated at the smiths' fires—which are, by the way, quite unlike the ordinary hearth, in respect that they are enclosed with brick walls, leaving only a small aperture for introducing the rods and for firing purposes—the rod is cut into short lengths of the size required, not by a self-acting machine, but by the workman himself, and these lengths are in turn put into dies, where they are shaped and headed by a hammer worked by the smith's foot. This machine is called an oliver, and there is one attached to each fire. Nuts are likewise made in the smithy to a considerable extent, but a flat bar of iron is used instead of a rod, and the machine on which they are made is called a fly, the latter being also worked by hand. A separate chimney is attached to each fire, and the shop is ventilated and lighted by large holes in the east and south walls. The fuel used is smithy coal, mixed with char, which gives an admirable fire, and produces very little smoke. Between the smithy and the other departments there is a small yard, in which a well has been sunk to the depth of 120 ft. An ample supply of water is thus continually at hand for the machinery. From this well the water is pumped up into a large iron cistern, which, when full, contains more than sufficient to supply the works for a whole day. An air-pump attached to the smaller engine is adapted to supply the boilers with water from the city mains, the well water containing such a large proportion of lime that its use in the boilers would be highly injurious. Small pipes are led between the principal machines and the large cistern outside, so that the tools are always kept at the requisite point of coolness.

Above the principal rivet shop there is a spacious finishing-room, where a number of women are constantly employed in threading the screws and nuts, and kindred work. The machinery in this department embraces 6 lathes, a planing machine, a vertical machine, and other smaller appliances used in connection with the finishing of bolts, rivets, nuts, and screws. Here, also, the machines used on the works are made, altered, or repaired. The work at which the women are employed, although it may not appear congenial to one's delicate sensibilities, is neither difficult nor harassing, but it is very dirty. At one kind of machine they are capping nuts—one of these being capable of capping 4 nuts at a time; at another they are polishing nuts, and at a third they are putting the thread on 2 bolts at a time. There is another machine by which the bolts are pointed instead of being turned. A shaft, from which pulleys and belts communicate with the various machines, runs from end to end of this shop, which is heated by the exhaust steam from the boilers. The drawing or scrap from the bolts and nuts is sold to brokers at the rate of 1s. 1d. per cwt., and after being mixed with other scrap it is sold to the forges, or otherwise disposed of.

Although we have indicated that bolts and nuts are made at these works as well as rivets, the manufacture of the latter is

carried on to a much larger extent than either of the other two. Shipbuilders, bridge-builders, and boiler-makers necessarily use an immense quantity of rivets, and it is from these sources that the rivet works are mainly employed. Some of the shipbuilding firms on the Clyde make their own bolts and rivets, but the majority of them are dependent upon Mr. Miller's and other works of a cognate description, where they can be better and quite as economically supplied.

It only remains to be added that the Stobcross Rivet Works are now so full of orders that operations are carried on day and night, and a further extension of the works is consequently in contemplation.

STARTING-POINT FOR A MODERN STYLE OF ARCHITECTURE.

From "The Building News."

How to bring modern architecture a little nearer to the level of modern wants and circumstances is, of all art questions, the most pressing. In fact, it includes them all. Give us an architecture as fit for our purposes as that of the Middle Ages was for theirs, and all minor problems will soon be solved. But the demand is an immense one. How much it implies, few of those who talk about developing a modern style ever seem to realize. A modern style is not to be invented by one man; it will not start into being in a day or a year. We are not of those who believe, either, that the best chance of obtaining it is to reject the past and begin on the "all original" system. There must be a nucleus around which new ideas can crystallize; there must be a solid foundation on which new additions can be built up. There must be, in short, some style or period of a style assumed as a basis, something in which we can alter what needs alteration, and retain what is worth keeping. The question is, what style affords the most hopeful starting point.

In trying to arrive at a conclusion on this subject, there is at least one circumstance in our favor. We are not left to judge of it merely by logic and *à priori* speculation. There is a far better guide before us—the teaching of experience. With no more trouble than that of walking about the streets of any large town, there are put at our disposal the results of innumerable experiments bearing on this very question. Within the last fifty years it would be hard to say what style has not been tried. Styles and shades of styles without number are being tried at this moment, till it is almost a puzzle to find two architects who employ the same one. Nothing, it is true, shows more fully the unsettled state of modern practice than this. Nothing so clearly measures out to us the distance we have to travel before we attain an architectural system of our own, as the fact that few of us can even agree as to which, of all existing systems, comes the nearest to it. One after another we have tried them all,—Greek, Roman, Italian, and Renaissance; English-Gothic, French-Gothic, Italian-Gothic, Gothic of all periods—Early, Middle, and Late; Romanesque, too, and Byzantine; not to speak of Moorish and Arabian. We have tried them separately, and we have tried them mixed, and after half a century so employed, it is surely not too soon to examine the result. Which has proved most successful in the past; which offers most promise for the future? To attain some general agreement on this question would be an immense step in advance. To pull all together, instead of all pulling in different directions, would soon revolutionize the state of affairs. Even if we could clearly decide what to reject out of all these styles, something would be effected. It would be no slight gain to prevent the extravagant waste of force that is now going on, to settle positively what roads could lead nowhere, and to save every one from wasting his time and trouble on them in future.

To state the objections to many of these styles as a starting-point may seem to most of our readers a needless task. They have practically decided for themselves that Gothic, in one or another of its phases, is alone deserving their attention. But even for those who have most resolutely fixed on their future course, it is not useless to recall the reasons why they have fixed on it. The adoption of Mediæ-

valism because it is the fashion, and its adoption because it comes nearest to what we really want, are two very different things. At the present moment, we have far too much of the former and far too little of the latter. The bulk of modern work could not be so lifeless and unreal as it is, if those who produce it had to account for and defend its characteristics. Its authors are aimlessly drifting with the tide —and should it turn, would drift just as aimlessly in a contrary direction. There is more hope of any class of men than of these. Future art will owe more to those who take up the very worst and absurdest of styles from genuine conviction, than to those who take up the best merely because the popular fancy of the hour may applaud it. The genuine Gothic architect of the day may look with respect on such works as those of Mr. Cockerell or Messrs. Thomson, of Glasgow; he may feel that the designer of the courts at South Kensington was a man and a brother; but what can he think of those who produce the regulation church or schoolhouse of the period? And the public speak of them, too, as Gothic architects; suppose them to be his special friends and colleagues! Of all the dead-alive architecture of the day, he must surely hate dead-alive Gothic the most. That writer might do no slight service who would set in the strongest lights the faults as well as the merits of modern Mediævalism; who, if such a thing were possible, would drive all its followers into following it with intelligence and discrimination; who would force them to decide how far to follow it—what part to keep and what to reject. Such a writer might take a candid survey of other styles, and tell the truth about them. He might insist on the good in them—for there is good in them all—a kind of good, possibly, beyond our reach, or not worth paying the necessary price for—and if so, this truth should also be made clear and unmistakable. But it is truth, and not half truth, that we want; we need not pretend that there is nothing admirable in any style but one, for fear we should desert that one which we have chosen. Those who have taken a course with their eyes open, and made up their minds with full knowledge of the facts, are not so easily to be turned aside. They can bear to recognize the merits of other systems besides their own; for they are either striving to introduce these same merits into their own system, or they see with perfect clearness that it is impossible so to introduce them without destroying greater ones.

A thorough examination, then, of the faults and advantages of the various architectural fashions now in vogue amongst us might lead to useful results. It is too great a subject to be even outlined here, and to many of our readers all its interest would probably be connected with one only of its divisions. They have decided that Gothic is preferable to anything else as a starting-point; but what especial phase of Gothic is best for the purpose is perhaps not equally clear to them. "Early Gothic," we shall probably be told, is the type selected; but Early Gothic may mean two very different things. It may mean, and most frequently, perhaps, does mean, in this connection, a half-developed tracery-system; it may also mean a system in which there is neither tracery nor any necessary tendency towards it. Which of these two is the best foundation for modern work—the incomplete Geometrical, or the perfected Lancet style? The question is no easy one to answer, and the beauty of early tracery windows has commonly decided it in favor of the type which admits them. We are not sure as to the wisdom of this decision. Tracery once allowed, it is not easy to stop its development. Some of our leading architects, having started years ago with its best and earliest forms, have been, and are still, going through a "decline and fall" of Gothic in their own practice. Their plate tracery has grown up into bar tracery—and this into more and more complex forms; the rest of their details have kept it company, and their work has passed on from Early to Middle Gothic, or Later. The breadth and freshness and simplicity which once characterized their work are gone. The hopefulness has vanished from it; the germs of a nineteenth century building style are no longer to be sought there; its authors have given up thinking for themselves, and have swallowed the Mediæval system whole. They "make it" A.D. 1371, and ignore the trifling fact that their clock is five hundred years too slow. It is the natural result of having accepted the principles by which Middle Age art grew old and died. It would surely be safer to

adopt those only by which it first attained perfection; the perfection of the pure Lancet period, which, had it never been exchanged for a puerile and frittered tracery style, might have held its ground against the strongest efforts of the Renaissance. The introduction of tracery was more, perhaps, than anything else, the destruction of Gothic. A pointed style, free from all, even the very slightest, germs of tracery, does not, like an opposite one, plainly contain the seeds of its own ruin. It will, we think, harmonize with a higher class of painting and sculpture, and will not demand an exaggerated quaintness in their productions in order to assimilate them to itself. It is strong, beautiful, and severe — natural and reasonable; fit for an age whose best characteristic is earnest study of facts rather than wild fantastic redundance of imagination.

A REVIEW OF THE TELEGRAPHIC SITUATION.

BY F. L. POPE.

From "The Telegrapher."

The period of time extending from 1864 to 1866 will long be remembered as one of the most exciting periods in American telegraphic history. At the close of the war telegraphic business seemed to increase to an extent before unprecedented. The facilities of the companies then in existence were taxed to the utmost, and rival and competing organizations sprung up in every direction. A sketch of telegraphic history, from that time until the present, may therefore not be entirely destitute of interest and instruction.

In 1864 the principal telegraph companies in the United States were the American, whose lines covered new England and the seaboard and Southern States, and the Western Union, who either owned or controlled all the lines throughout the Western and Northwestern States.

On the 1st of August, 1864, the United States Telegraph Company was organized, by combining several detached and feeble competing lines, and at once proceeded to develop an extensive and vigorous competition with the old companies for the telegraphic business of the country. During the succeeding year this company extended their wires with great rapidity, and secured a large amount of business. The apparent success of the U. S. Company stimulated other enterprises of the kind, and two more competing lines were opened for business on the 2d September, 1865—Bankers and Brokers', from New York to Washington, and the "Insulated," from Boston to Washington. The Franklin Company, between New York and Boston, connecting with the Bankers and Brokers', opened for business on the 16th of January, 1866. The latter company made a fatal mistake in attempting to secure business by cutting the rates 33 per cent., which move was promptly followed by a reduction of 50 per cent. by the U. S. Company, in which all the other companies were necessarily obliged to join.

The United States Company had by this time extended their lines in every direction from New York east to Portland, south to Richmond, and west to Chicago, St. Louis and Omaha, competing with the old companies for the business of the larger cities and towns, with a great degree of success, and were also at work on a line to the Pacific coast. Meantime there were no less than four different companies competing with each other at ruinous tariffs for the business of the best telegraphic territory in the country—that between Boston and Washington.

On the 1st of March, 1866, a most important move was made on the telegraphic chessboard by the consolidation of the United States with the Western Union Company. The causes which led to this result have been pretty thoroughly canvassed, and need not be referred to at length. Extravagant and wasteful management, especially in the earlier stages of the enterprise, and an injudicious distribution of wires—the extent of the system in the West being utterly disproportionate to the limited facilities between Buffalo, Pittsburg and New York—were the principal causes of the failure of the enterprise.

At the time this consolidation took

place, the Western Union Company had 44,000 miles of wire, and the United States Company about 16,000. The absorption of the United States line gave the Western Union control of a large number of lines running through the territory of the American Company, and for a time it seemed that a fight between these two companies was imminent. If the Western Union attempted to operate these lines in competition with the American, the latter proposed to extend their system into the Western States, and thus inaugurate a general war. The only other alternative was another consolidation between the Western Union and American Companies, which was finally arranged and carried into effect July 1, 1861. This gave the Western Union 30,000 more miles of wire, making a total of about 90,000 miles, and its managers considered that their long hoped for monopoly of the telegraph business of the country was at length substantially an accomplished fact.

These various consolidations disposed of all the competing lines, except the Insulated, Franklin, and Bankers and Brokers', between Boston and Washington. Let us glance for a moment at the history and condition of these lines.

The "Insulated" Company was projected with the idea of constructing a line whose wires should be entirely enveloped with some insulating material, thereby enabling them to work well in any state of the weather. This plan for some reason was abandoned, but a well constructed line of four wires was put up between Boston and Washington. No pains or expense were spared to make this a model line, but the style of insulation adopted—probably about the worst that has ever been devised—and the old story of extravagant and inefficient management, together with the reduction of rates before referred to, soon got the company into financial difficulties.

The Bankers and Brokers', at the time of its construction, was probably about the best built line in the country. It had four wires from New York to Philadelphia, and two from Philadelphia to Washington. The enormous profits made by the contractors who built this line, and the debts in which it entirely became involved, from lack of proper business management, involved it in pecuniary embarrassment, from which subsequent good administration failed to extricate it.

The Franklin line of two wires from New York to Boston, at an early period of its history, passed under the control of practical telegraph men, who secured the property at a reasonable cost and worked it with a good degree of success. This company secured the control of the Insulated lines on the 1st of May, 1867; but the debts of the latter company, and the wretched condition of its wires, arising from bad insulation, have proved a heavy load for the former company to carry.

Up to the latter part of 1866 no serious competition to the Western Union Company had developed itself, other than the lines above referred to between Boston and Washington, but efforts were being made in various other parts of the country to organize another system of competing lines. The first fruits of this movement appeared in the opening of a new line, under the name of the Pacific and Atlantic, between Baltimore and Pittsburg, which took place on the 10th of December, 1866. This enterprise was in the hands of a number of prominent Pittsburg men, who soon began to show that they meant business. Reaching Philadelphia and New York by means of the Insulated wires from Baltimore, they soon extended their wires into the oil regions, and also towards the West. In 1867, two wires were built over the Pennsylvania Railroad from Pittsburg to Philadelphia. On the 1st of May, 1868, this company had 1,853 miles of line and 3,244 miles of wire. In October, 1868, they purchased the lines of the Southern Telegraph Company, extending from Cincinnati to Nashville, Louisville and Memphis, which were built in 1867. In October, 1869, they purchased the lines of the Mississippi Valley Telegraph Company, extending from Chicago to Dubuque, St. Paul and St. Louis, embracing about 2,500 miles of wire, which had been built during the years 1867 and 1868. In the following month their lines reached Chicago, and within a few days afterwards opened between Philadelphia and New York. Since that time this company have been engaged in adding to their facilities on existing routes, and in extending their southwestern lines towards New Orleans.

The Atlantic and Pacific Company

originated in New York, and was organized in 1866. Active operations were commenced early in 1867, and on the 15th of October of that year the line was opened for business between New York and Buffalo, and Cleveland was placed in connection on the 8th of January following. From various causes the work went on rather slowly the following year, and it was not until November 3d, 1868, that the Chicago office was opened for business. The Great Western Company, working in connection with them, had already reached Milwaukee, and was subsequently extended to Omaha. Branches were built by the Atlantic and Pacific Company to Detroit and Cincinnati, and other minor points, as their work progressed. In June, 1870, an arrangement was made placing the control of the Pacific Railroad wires in the hands of this company, and on the 10th of that month communication was established with the Pacific coast.

In the meantime a number of tributary lines, of more or less importance, had been constructed to work in connection with the lines already mentioned. The Dominion Company of Canada commenced operations in 1868, and in connection with the People's Company have constructed quite an extensive range of lines in the Dominion, connecting with the A. and P. Company at Suspension Bridge. The International line from Boston to Bath, Me., was opened Jan. 26, 1867, and has since been extended to Bangor.

Name of Company.	Miles of Poles.	Miles of Wire.	Number of Offices.	Number of Operators.
Atlantic and Pacific	3,744	8,313	238	352
Pacific and Atlantic	4,155	8,280	167	300
Franklin	800	2,780	76	100
Bankers and Brokers'	284	1,095	37	43
International	412	743	51	59
Philadelphia, Reading and Pottsville	505	926	115	180
Great Western	1,500	800	49	54
Southern and Atlantic	370	752	10	10
Dominion	629	1,116	35	40
People's	250	500	20	24
Delaware River	248	248	25	25
Northern	130	130	12	12
Total	14,033	25,683	830	1,200

The Northern Telegraph Company started from Boston with the intention of reaching Montreal, but stopped at Bristol, N. H., to which place it was opened in September, 1867.

The extent and importance of the competing lines in the United States at the commencement of the present year may be seen from the preceding table, which was compiled from official sources. A number of lines of small importance and extent, which exchange business with the competing lines, are not included in the table, and amount, probably, to two or three thousand miles of wire in addition.

The Southern and Atlantic Company have only commenced operations at a comparatively recent date; they are building from Washington to New Orleans—which point they will probably reach during the present year.

It will be seen that the competing lines, including the various minor lines connecting with them, comprise nearly twice as many miles of wire as the United States Company did at the time of its consolidation with the Western Union. A consolidation of these various lines into one organization would enable it to compete very successfully with its powerful rival. Its facilities would be far greater than those of the United States Company, not merely on account of having more wires, but of a better class, and distributed in much better accordance with the requirements of the business. It would have 6 wires from New York to Boston, 15 between New York and Philadelphia, 8 between Philadelphia and Washington, 3 from New York to Buffalo, and 4 from New York to Pittsburg. Thus the important routes are very well provided for.

The true policy of these competing companies is the consolidation of interests into one compact and powerful organization, which shall be able to compete successfully with their great rival for the telegraph business of the country. This course has been persistently advocated in the columns of "The Telegrapher," as the only one which can enable them to secure pecuniary advantages, and permanently maintain the competition which the public imperatively demand, and for which so much capital has already been invested.

This brief sketch of telegraphic history demonstrates the futility of the efforts of any combination, however powerful, to maintain a monopoly of the telegraph business in this country. The people, by repeated investments, in spite of the fact

of continued loss and sacrifice, have shown that they will not submit to a telegraphic monopoly. Only in the hands of the Government, and by Congressional enactment, as in the case of postal communication, can such a monopoly be sustained. The prospects of the establishment of a Government Telegraph System are not very bright, at least for some years to come, and in the meantime the facts here collated are commended to the serious consideration of all interested parties.

ON THE STRENGTH OF PORTLAND CEMENT.

From "The Builder."

At the Institution of Civil Engineers, on April 25th, Mr. Vignoles, F. R. S., president, in the chair, the paper read was on "Further Experiments on the Strength of Portland Cement," by Mr. John Grant, M. Inst. C. E.

In a previous paper the author had stated* that "further experiments were desirable, on the strength of and adhesion between bricks and cement under varying circumstances; on the limit to the increase of strength with age; on the relative strength of concrete made with various proportions of cement and ballast," etc. The experiments described in this paper were made with the view of throwing additional light upon these points, and might serve to show those interested in the subject the direction which their inquiries might advantageously take, and the large field yet open for their labors.

Before describing the new series of experiments, some of the points in the previous paper were reviewed.

The next step was to establish the conditions to be observed in the following new series of experiments:

A. On the strength of Portland cement tested by tensile strain at different periods, from 1 day to 12 months, mixed by hand and ground in a mortar-mill.

B. On the adhesion between bricks cemented with Portland cement and lime mortars, tested by tensile strain at the end of 12 months.

C. On the strength of Portland cement neat, and with different proportions of sand, tested at the end of 12 months, by compression in a hydraulic press. Size, 9 in. by 4½ in. by 3 in.

D. On concretes of different proportions of Portland cement and lime, with gravel, sand, and other materials, tested at the end of 12 months by compression. Size 12 in. by 12 in. by 12 in., and 6. in. by 6 in. by 6 in.

For these experiments 38 bushels of Portland cement were procured; the gross weight being 4,300 lbs. 11 oz., or 113.176 lbs. per bushel. When sifted through a sieve of 400 holes per sq. in., this was reduced to 4,201 lbs. 4 oz., or 110.56 lbs. per "striked" bushel. About 36 lbs. were afterwards rubbed through the sieve; 34 lbs. would not pass, and there was a loss of 29 lbs. A certain quantity of cement was sifted, when it was found that the gain by sifting was about 14 per cent.

The following were the weights per bushel and per cubic ft. of the materials used in the new series of experiments:

Materials.	Weight of 1 bushel. lb.		Weight of 1 cubic ft. lb.
Portland cement	110.56	....	86.375
Sand and ballast	123.40	....	96.400
Portland stone	98.00	....	76.560
Broken granite	116.00	....	90.625
" pottery	113.00	....	88 280
" slag	107.00	....	83.594
" flints	126.00	....	98 440
" glass	120.00	....	93.750

Table VI., Series A, gave the strength of the Portland cement used throughout these experiments at different periods from 1 day to 12 months; first, mixed by hand, and next, mixed in a mortar-mill for 30 min. In the first case the maximum strength seemed to have been attained at 4 months; in the second, at 1 month; the greatest strength of that mixed by hand was about double that mixed in a mortar-mill. The hand-mixed cement maintained its strength; the mill-mixed declined from its maximum at a month to the end of the experiments. This result was probably due partly to the process of crystallization, or setting, having been interrupted by the continued agitation, and partly to the destruction by

* *Vide* Minutes of Proceedings Inst. C. E., Session 1865-6, vol. xxv., p. 66.

attrition of the angular form of the particles.

Table VII., Series B, on the tensile strain required to separate bricks cemented together with Portland cement and lime mortars, would require to be greatly extended before trustworthy deductions could be made from them. In the case of perforated bricks, the cement mortar seemed to act as dowels between the bricks, and the results were consequently high. The Suffolk and Fareham red bricks adhered well to the mortar.

Table VIII., Series C, on the strength of Portland cement bricks tested by crushing, was, so far as it went, very instructive. As a rule, strength increased with density. When the cement was in less proportions to the sand than 1 to 2, or 1 to 3, those dried in air bore a greater pressure than those kept for 12 months in water. This would lead to the inference, that when the quantity of cement was small, bricks or blocks of concrete should be kept some time out of water, to harden before being used. Contrasting the strength of these concrete bricks with different clay bricks, it was found that down to the proportion of 6 to 1 the former compared favorably. Thus, bricks made of neat cement bore a pressure equal to that of Staffordshire blue bricks or best Fareham red bricks. Bricks made in the proportions of from 2 to 1 to 6 to 1 of cement were equal to picked clay bricks of 6 varieties.

The D series showed the strength of concrete bricks made with Portland cement, mixed with various materials in different proportions, and crushed after being kept a year, half of them in air and half in water. The general deductions were, that those made with the largest proportion of cement were the strongest, the strength being nearly in proportion to the quantity of cement. Tables were given of the strength of 12 in. and 6 in. cubes of concrete made with ballast, Portland stone, broken granite, pottery, slag, flints, and glass, mixed with Portland cement in the proportions of 6, 8, and 10 to 1, and compressed. Half was kept in water for 12 months. The most prominent result of these tables was that concrete made of broken stone or broken pottery, was much stronger than that made of gravel; due, no doubt, partly to the greater proportion of cement absorbed in the latter case in cementing the finer particles of sand, and partly to the want of angularity in the gravel. Compression and an increase in the proportion of cement alike increased strength. In making concrete bricks or blocks of moderate size, compression might be applied with advantage; but with large masses of concrete it would be difficult to do so without running the risk of interrupting the process of crystallization or setting, which commenced immediately on the application of moisture. The cost of labor so applied would therefore be better employed in a larger admixture of cement.

The different modes of using Portland cement in the construction of sewers were described ; in some cases only as a foundation or as a backing for brickwork; in others sewers, 4 ft. 6 in. by 3 ft., of concrete were lined with half-brickwork; and in other instances sewers were formed entirely of concrete, in the proportions of 1 of cement to 6 of sand. The cost of this concrete was less than half that of brickwork; but if rendered inside with cement, it was about the same as if lined with half-brick—perhaps the cheapest form of sewer, combining strength with soundness. Sewers and culverts of almost any size might be made on this principle. Sewers made of concrete, and not rendered inside, though somewhat cheaper, had one practical disadvantage in busy thoroughfares, inasmuch as they required a long length of centring, on account of the slow setting of the concrete, and it was, therefore, necessary that about double the length of trench should be open at one time. The cost of a concrete sewer, 4 ft. by 2 ft. 8 in., was 10s. per lineal foot, exclusive of excavation. Under the same contract, a brick sewer, of the same size, 9 in. thick, cost 16s. 6d. Another concrete sewer, 7 ft. 1 in. in diameter, cost 16s., or, inclusive of earthwork, side-entrances, junctions, etc., about 23s. per lineal foot. This sewer was, in some respects, exceptional, inasmuch as it consisted of little more than an arch over a previously-existing invert. The lower half was, however, rendered with cement and sand, in equal proportions, 1 in. thick. Everything being taken into consideration, the most economical combination was 4½ in. of brickwork in cement, and the rest in concrete. Another sewer, 9 ft. by 9 ft., of concrete,

with a lining of 4½-in. brick in cement, was mentioned.

In the construction of the Albert, or Southern Thames Embankment, it was originally intended to form the wall of brickwork, with a granite facing; but after about a fourth part of the work had been executed, 14,335 cubic yards of Portland cement concrete, made in the proportions of 6 to 1, at 11s. per cubic yard, were substituted for an equal quantity of brickwork, at 30s. per cubic yard.

From the experience already gained in the use of Portland cement concrete, there would seem to be hardly any limit to the purposes to which it might be applied. It was gradually being brought into use in the construction of dwelling-houses in different parts of the country, and there was no doubt it would be still more extensively employed in the construction of docks, piers, breakwaters, and other massive engineering works.

Many experiments had been made in the manufacture of bricks of different proportions of Portland cement and sand, and these were equal in strength and appearance to most kinds of clay brick. Where concrete could be used in a mass, it was cheaper than when used in the form of blocks, and still cheaper than in the form of bricks. In 1867, a number of arches were formed with "Bétons Agglomérés," by M. Coignet, under the steps leading from Westminster Bridge to the Albert Embankment; also about 40 ft. of sewer, 4 ft. by 2 ft. by 8 in., in the Camberwell Road. Similar arches and sewers were constructed of Portland cement concrete, and the general result was that the Portland cement concrete was both stronger and cheaper than the béton.

Tables were given of the strength of 589,271 bushels of Portland cement used during the last 5 years on various works south of the Thames, showing an average tensile strain at the end of a week of 806.63 lbs., equal to 358.5 lbs. per sq. in., being an improvement on that reported 5 years ago of 200 lbs. on the breaking area of 2¼ sq. in., or 89 lbs. per sq. in. The quality had not only been maintained, but had continued to improve. The strength at the end of 30 days of 37,200 bushels of the same cement, as ascertained by 1,180 tests, averaged 1,024 lbs., equal to 455 lbs. per sq. in., showing an average of 234 lbs., or 30 per cent. over the cement tested at 7 days, which broke at 790 lbs. Wherever the nature of the work would admit of it, tests at the end of a month would be found more satisfactory than if made earlier, as heavy cements, though the strongest eventually, were the slowest to set. The standard originally specified was 400 lbs. on 2¼ sq. in.,and this was soon afterwards raised to 500 lbs., or 222 lbs. per sq. in. This had since been increased to 350 lbs. per sq. in., or 787 lbs. on the breaking area at 7 days. For the purpose of comparison the same sectional area at the breaking point (2.25 sq. in.) had been retained. Further experience had confirmed the earlier conclusions, that the strength of Portland cement increased with its specific gravity, its more perfect pulverization, and its thorough admixture with the minimum quantity of water in forming mortar. Heavy cement, weighing 123 lbs. a bushel, like that referred to in Table XVIII., took about two years to attain its maximum strength used neat; but by the admixture of sand or gravel, cement, mortar, or concrete was reduced in strength, and set less rapidly than neat cement. Roman cement, though from its quick setting property very valuable for many purposes, deteriorated by exposure to the air before use, and was about double the cost of Portland cement, if measured by strength. In making cement concrete, it would from this seem desirable to spend no more than was absolutely necessary to effect a thorough admixture of the cement with the sand and gravel.

Upwards of eighty messages were despatched from and received at Madras on the first two days after the opening of the Madras and Penang telegraph line. The Indian Government is about to erect an additional wire between Madras and Bombay, in anticipation of the utilization for business of the cables to China and Australia.

The Hongkong-Shanghai Telegraph Cable.—The Great Northern Telegraph, China and Japan Extension Company have received information that the laying of the Hongkong-Shanghai cable was successfully completed on the 29th of March, and that the cable is in perfect condition.

THE MINERAL RESOURCES OF CHINA.

From "The Mining Journal."

Although comparatively little is known in this country concerning mines and mining in the Chinese Empire, it seems certain that they are not altogether neglected. Of the mineral wealth of Szechuen, and the western provinces, only a mere sketch can be given. The commonest product under this head is coal, which is found in abundance everywhere, from below Pa-tung-hien to Chungking. It is worked by a cheap and easy process on the hill sides, is sold at the pit's mouth in some places at as low as 30 cash per picul (say 2½d. per cwt.), and is very generally consumed both for domestic and manufacturing purposes in all parts of the country. Around Chungking itself the coal mines are particularly productive, and constitute a rather important item in the industry of the neighborhood. The best quality of coal is said to be that found near Khwei. The only complaint the natives have to make against it is that it burns too fast; hence they economize by pounding it small and mixing with earth, so forming a kind of patent fuel, which they call *tan-yuen*.

The metal trade is not regarded as of very great importance in Szechuen, but metals generally are under Government monopoly, or are permitted to be worked under Government license. Gold bars are brought from Kweichow and Yunnan, and are also made out of the gold dust found in the bed of the Kinshakciang or Golden Sand river, by which name the Upper Yang-tsze is sometimes known, and which is no mere fanciful appellation. The waters of the river are undoubtedly charged with gold, which is annually deposited among the pebbles in its bed. On the subsidence of the summer flood the natives commence washing for gold, beginning at a short distance below Wan, and extending to the upper part of the river.

The occupation is not very remunerative—the workmen have little left after paying the license to the authorities; and in case they did improve their fortunes by a successful search, there is little doubt that the taxes would be increased. Silver comes from Yunnan and Kweichow. Copper and white copper (petung) are found in the province of Yunnan and Kweichow, and are taken for sale to Jinhwaiting. Whitecopper also comes from Hwuylichow, in Ningyuanfoo, in Southern Szechuen. Only a small quantity of Chinese red copper comes to market at Hankow. Spelter (peyuen) comes from the same quarter and is also collected at Jinhwaiting. It is used to mix with copper, to manufacture, cash, and is at present reported to be sent in large quantities to Japan. Tin (seih) is found in Yunnan, also in Hoonan and Kweichow. The produce of Yunnan and Hoonan is collected at Yuenchowfoo, the other at Jinhwaiting. There are several qualities, the best being called tienseih. Lead (hihyuen) is said to come from Tungchuenfoo, in Yunnan. Quicksilver is found in Kweichow; sulphur in small quantities there also, and in various parts of Szechuen. Iron is very abundant and very cheap in Szechuen. Chingyuchang, in Chingtoo prefecture, is mentioned as a place where it is produced in large quantities; in Yunnan it is also abundant, and used locally.

The province of Kweichow is, perhaps, the least known of the eighteen into which China is divided. It has suffered severely by a war with the mandarins, cholera, and other epidemics, so that one town, for example, of 50,000 inhabitants was reduced to 200 families, of which but six belonged originally to the place, the remainder being immigrants from Szechuen. The aggregate result has been to reduce the population from 6,000,000 to less than 1,000,000. The Catholic bishop resident at Kweiyang, the capital, who passed down the Yangtsze last May, described the country between his residence and the borders of Szechuen as a depopulated jungle, and the trees as having been everywhere cut down by the ill-paid soldiery for fuel. Kweichow, though less fertile than many other provinces of China, has still elements of prosperity in its available resources. It is rich in mines of lead and copper, but especially of quicksilver, which latter were being worked to great advantage previously to the late rebellions, but have not been since resumed.

The province of Hupeh contains, as far at least as is known, but little coal; but it

is always necessary to remember that what the Chinese call bad coal, and not worth working, may after all overlie some really valuable deposits. Nowhere in Hupeh are there any largely worked or important mines. At some hills, not far from Anluifu, on the Han river, a poor earth coal is found and used in the coarse pottery works in that city, but is not exported elsewhere. At Ichangfu, on the borders of Szechuen, a rather better coal is found, and exported to places in the immediate neighborhood. In the neighboring province of Hunan large and valuable fields of bituminous coal exist, and have long been worked. The district is traversed from north-east to south-west by the Hsiang river, the principal feeder of the Tungtinghu. It is mountainous, and intersected by small streams, whose waters are subject to all the vicissitudes incidental to mountainous districts, and the continual, sudden, and very violent rains peculiar to Hunan do not diminish the dangers from floods either to the mines or the boatmen conveying the coal down to the depot at Hsientanhsien. The coal field lies in the jurisdiction of the three prefectures of Yungchowfu, Henchowfu, and Paochingfu, and may be roughly estimated as extending about 30 miles from north to south, and about 33 from east to west. Near Paochingfu a non-bituminous coal, called iron coal, is found, and is extensively used in potteries, and for smelting iron; it is exported in considerable quantities, and in the distilleries, felt factories, and forges at Hankow and elsewhere. The chief mines for this coal are stated to be at Nieumassu and Chiangshuiwan, about 30 li from the prefectural city.

With regard to the mines themselves, they are driven horizontally into the sides of the hills, and often penetrate them to a considerable depth. These shafts, or rather passages, are of no great size, and average about 4 ft. wide by 6 ft. high, and necessitate the miners working in a stooping posture; their roofs are propped up at intervals by wooden supports, and the rotting or breaking of these is a fruitful cause of accident, men being often crushed to death by the displacement of portions of the roof. Still more dangerous are the floods and heavy rains which are frequent in Hunan, and many miners are annually destroyed by the sudden flooding of the mines, or by the destruction wrought in the roofs and sides of the passages by the damp and wet. Fire-damp, however, so fatal in English mines, seems unknown, or nearly so, to the Chinese more simple methods of excavation, though it is stated it occasionally appears, but never in very large quantities. Agreeably to Chinese customs the system of co-operation seems generally prevalent, and each mine is the property of one or more families, who contribute the men and the material for working it, afterwards dividing the profits among themselves. As the hills are the property of the State, large proprietors are unable to monopolize these sources of national wealth, and no rent troubles these humble mine owners beyound the land tax universally due to the Emperor from the eighteen provinces.

In addition to the great coal field above treated of, there remain two other small districts, one in the extreme south of Hunan, in the magistracy of Hsintienhsien, whose produce is said to be considerable, and of value, but which is all sent southwards into the adjacent provinces of Kuangtung and Kuang-hsi; no very accurate, reliable, or detailed information can, therefore, be obtained about it in Hankow. The other is in the magistracy of Loong-shan-hsien, in the prefecture of Yung-shun-fu, in the north-west corner of Hunan, bordering on Szechuen. This coal field is reported to be extensive, and was worked as far back as the times of the Ming dynasty, but it is now said to be exhausted, and a little, but very inferior, coal is obtained from it. It is, however, by no means impossible that foreign skill might discover fresh deposits deeper down in the earth, and render once more valuable these now nearly useless mines, as it is likewise certain that acquaintance with the foreign methods of mining would render still more productive the great central coal field of Hunan, and the possible more universal introduction of steamers for the navigation of the inland waters of China will soon render necessary what is now a mere matter of speculation—namely, that the practically unlimited resources of fuel in Hunan should be opened up and rendered fully accessible to foreign skill, energy, and capital. With how great advantage to the people of China, it is needless to state. No accurate statistics

are obtainable of the amount of coal annually brought down from Hunan. The foreign steamboat companies consume nearly 16,000 tons per annum, and the extent of country depending for supplies of fuel on Hunan must be very large. The valley of the Yang-tsze is probably the principal market, and the vast population dwelling on its banks appears to depend for its fuel chiefly on Hunan.

Returning to Szechuen, it should be mentioned that salt is another important source of its wealth. It is produced in many parts of the province, as in Foochow and in the prefecture of Khwei, but the largest supplies are found in Wotungkeaou, in Keatingfoo, where *hihpa*, a white kind, is made from springs; in Sz'lewkin, in Fooshunhien, where another white kind, called Sz'yen, is made; and in Shayhunghien, in Tungchuenfoo, whence it comes in black and white blocks, some white, and some very dirty. A license is necessary to enable a merchant to deal in salt, which is said to cost 20,000 taels, besides paying which the applicant is supposed to find security for his possession of sufficient capital to carry on the trade. The license remains in the family, transmissible from one generation to another, but each successive holder is required to pay 10,000 taels to the mandarins, besides making them frequent presents. So the matter was described to us, but in point of fact the cost of a salt license probably depends on the terms which the holder of it can succeed in making with the mandarins.

The salt trade of Szechuen received a very important stimulus from the closing of the navigation of the lower Yang-tsze, in consequence of the capture of Nanking, and the occupation of the river by the Taepings. Up to that time the whole of the provinces of Hoopeh, Hoonan, Kiangsi, and Anwhuy, had been supplied with the "Hwai-yen" salt, so called from its passing Hwai-kwan barrier, to its depot at Yang-chow, all other salt being contraband. But when communication with Yang-chow had been stopped, the Viceroy Taou petitioned the Emperor to permit the Szechuen salt to be brought for sale to Hankow, which was, of course, granted, and Szechuen salt kept possession of the market until the opening of the river navigation by foreigners in 1861. The "Hwai-yen" salt again began to come to Hankaow in 1862; and for some years past Tseng-kwo-fan has been making great exertions to bring the trade back to its old channel, petitioning to have the Szechuen salt again interdicted in Hoopeh.

Time will be required, however, before the trade can be organized on its former footing, for the old monopolists, or Yen-shang, were dispersed by the rebellion, and the mandarins have been obliged to grant licenses to new men of inferior standing, called Yen-fan. The authorities are, however, making every effort to place the matter on a permanent basis, compelling applicants for license to go to Peking, and making the license not transferable. The Hwai-yen salt arriving in Hankow is placed under the control of an officer, called "Tuh-seao Hwai-yen-keuh," who regulates the price at which it shall be sold, and the order in which the boats shall discharge, the owner having no voice in the matter. With Szechuen salt it is different, for having paid duty at Ichang on the way down, it is henceforth free from official interference.

The North German Lloyds.—This great undertaking has now 3 steamers running on a Bremen and Aspinwall line. The line comprises 3 new iron screw steamers of 3,000 tons burthen each, and named respectively the King William I., the Crown Prince Frederick William, and the Count Bismarck. These vessels were built on the Clyde, and they have direct-acting engines of 300-horse power nominal. The run between Bremen and Aspinwall is to be made in 18 days. After discharging at Aspinwall, the steamers will proceed to Laguayra, touching at Savanilla and Puerto Cabello.

It is expected that the broken section of cable between the Islands of Shapinsay and Eday, on the Shetland circuit of the Orkney and Shetland Islands telegraph, will be repaired about the first week in May. Owing to the rapid tideway and strong currents, from the exposed position of the Stransay Frith to the North Atlantic Ocean, the operation attending the repair will be one of great difficulty and danger.

ON STEEL AS APPLIED TO SHIP BUILDING.

By J. B. HOWELL, Esq.

From the "Journal of the Society of Arts."

In the year 1853, I called the attention of shipbuilders and engineers generally to the value of mild cast-steel as a material especially adapted for shipbuilding and kindred purposes, and for a long time I failed to make any valuable impression upon those I thought most likely to entertain the subject. I was not merely unsuccessful, but I found, in many instances, a positive aversion to the use of steel for constructive purposes. This aversion, I have no doubt, was caused by the habitual thought of public opinion respecting steel being synonymous with brittleness. Finding this objection so constantly occurring, it suggested to my mind the necessity of giving it another name, and after about two years of fruitless effort, I introduced it as "Howell's Homogeneous Metal." This was the origin of the successful application of steel for boilers, tubes, ships, and locomotive fire-boxes. Messrs. Laird, of Birkenhead, constructed the little vessel called the "Ma Robert," for the Livingstone expedition. This is the first instance of the application of steel for shipbuilding; but since that time, mild cast-steel has been used very extensively for this and other purposes, where strength and lightness is a first consideration. We are now enabled to make steel suitable in the highest degree for shipbuilding, and I beg to call your attention to the samples exhibited. All these samples have been bent cold, which is a simple and safe test for steel plates; and some of them, before bending, have been heated to a red heat and plunged into cold water, which is a doubly sure test; these particular pieces are marked "A," but they do not appear to have suffered from the severe ordeal they have passed through. The samples are bent to show the angles to which the various thicknesses of plates should be bent, as a proof of their suitability for ship plates. The extreme test of 180 deg. is beyond the necessary test for plates of this character, but plates up to ¼ in. in thickness should always bear bending to that degree. The steel may be easily sheared, punched, caulked, and welded, and is 50 per cent. more rigid than iron. The term steel can barely be applied to this metal, as the very small amount of carbon it contains would prevent its being put in the same category as steel. The samples on the table contain 0.2 per cent. of carbon. This, I consider, should be the maximum quantity of carbon in steel intended for shipbuilding; for all plates containing this quantity of carbon never fail to give the required tests practically. We have discovered, in our long and extensive experience, certain irons as being the most suitable for the manufacture of these plates, and as there is no reasonable limit to the supply of these irons, there is no difficulty in turning out large quantities of these plates regular in their manufacture. The strength in tension of this steel is about 36 tons per sq. in., and the limit of elasticity about 23 tons. From this it can be seen that the rigidity of mild cast-steel is nearly two-thirds of its ultimate breaking strain. The limit of elasticity in iron is only one half of the breaking strain. Steel is, beyond doubt, stronger than iron; it is much stiffer and far more ductile; and, I think, were it used only for the skeleton of ships plated with iron, it would be a great gain in strength and stiffness of the whole structure.

Steel plates of 1 in. and less in thickness will resist the impact of shot much better than iron. During the experiments at Shoeburyness, conducted by the Iron Plate Committee, and referred to by Sir William Fairbairn in the "Transactions" of the tenth session of this institution, steel plates ¼ in. thick were found to have a resistance equal to iron plates ½ in. thick, and steel plates ¾ in. thick were equal to iron 1 in. thick, and steel plates 1 in. thick had a resistance exceeding iron plates 1¼ in. thick, but not equalling iron plates 1½ in. thick. The steel plates 2½ in. and 3 in. thick had no value against the impact of shot, and the first shot in each instance shattered the plates. This result we were quite prepared to expect, as our mechanical appliances were not equal to the successful manufacture of large, thick plates. To insure ductility in mild steel plates we require a blow or

squeeze sufficiently great to change the granular structure of the cast metal, so that, when broken by tension, it has a conchoidal fracture, or, as it is understood in the trade, knock fibre into it. The market price of these plates, also angles and bars, is from £25 to £30 per ton—a price, I think, sufficiently low to create a demand for them; for although it may seem a large price compared with ordinary ship-plate iron, it will be found economical to use it, not only in the durability of the ship and in repairs, but in the greater safety to life and cargo.

Many persons who have used steel for constructive purposes have even now a great objection to it. This has entirely arisen from inferior and irregular manufacture, due as much to the consumer as the maker, for the cupidity of both has in many instances induced the adoption of a low-priced article, which has failed to give satisfaction. Had manufacturers been careful to see that plates had what I consider the requisite characteristics for constructive purposes, and which are not difficult to determine, I believe the steel of to-day would not only be the future of iron, as Mr. Scott Russell has said on a former occasion, but had the proper precaution been taken in selecting the proper material, the steel of the past would have been the present of iron. It is desirable, where convenient, that the drill should be used instead of the punch in perforating the rivet holes in all steel plates; and I would further advise that, as soon as possible after their manufacture, they should be well payed, and, where convenient, submerged in boiling linseed oil. I have found in my experience that plates thus coated, after three years' exposure to the weather, have not shown the slightest tendency to corrosion, though subjected to alternate wet and dry. I consider the life of the plates will be lengthened greatly by this process, and the plates will take the paint much better after it. It is most important that destructive oxidation should be avoided as much as possible. The newly-formed oxide arising from the heat of the furnace does not decay until exposed. The oxide formed on steel plates in the fire is much more tenacious than that formed on iron, and forms more completely part of the plate, being difficult to remove without exposure or abrasion.

I have carefully avoided drawing comparisons between different qualities and makes of steel, but have confined myself to a steel which I consider the most suitable for shipbuilding, taking into consideration the most suitable material, and keeping within the price that I conceive may be paid to make it commercially profitable. Where great strength is required, irrespective of cost, then I should recommend steel, such as the armor plates referred to earlier in my paper, the breaking strain of which, under tension, is 46 tons to the sq. in. I would on no account, as far as my experience enables me to judge, use a steel of higher tensile strength than this, as every ton gained in strength beyond this limit is at the cost of ductility, which is important in all structures that are liable to sudden concussion; not but that you can get steel of higher tension with great ductility, but 40 tons is within the limit of certainty. The limit of elasticity of this steel is 30 tons per sq. in. This quality of plates is extensively used for locomotive fire-boxes, a great number of which are now in use on the Scottish Central Railway, giving the fullest satisfaction; some, indeed, have been working upwards of 9 years. The market price of these plates is £40 per ton, a price which has always prevented shipbuilders from entertaining the idea of using them for shipbuilding.

THE Japanese have abandoned the old method of printing from wood-cuts alone, as learned from China, and are establishing type founderies, electrotyping, and stereotyping establishments. They are being instructed by Europeans and Americans, and large orders for material have been received in the United States. With the Roman type will come the use of our language.

THE following figures serve to show the magnitude of railway traffic in England and Scotland: On sixteen of the leading lines of road there are 7,925 locomotives, 17,636 passenger cars, 135,990 freight cars, 8,575 cattle cars, and 73,750 coal cars.

THE tower on the Brooklyn side of the East River bridge is going up rapidly.

ON THE CONDITION OF CARBON AND SILICON IN IRON AND STEEL.

From "The Journal of Iron and Steel Institute."

No one can examine the statements contained in metallurgical works, regarding the condition of carbon and silicon in iron and steel, without being struck with their vagueness, and the unsatisfactory state of our knowledge of this important subject. That these elements do exist, in some form or other, and that they exercise an all-powerful influence upon the nature of the metallic compound, is admitted by all; while in the case of carbon, at least, it is now generally allowed that it may exist, either diffused through the mass, as graphite, or be present in some form of combination with the iron. But there are no proofs that this diffused graphite, or "kish," as the workmen term it, when it occurs on the surface, is pure carbon, nor any very satisfactory data as to the nature of the combination of iron and carbon; and it is only necessary to state a few of the theories on the latter point, to show that we require more workers in this field of research, to clear up the mist in which the subject is at present shrouded. As a small contribution in this direction, the following results are submitted to the members of the Iron and Steel Institute.

Thus, while Berthier believed he had discovered a simple compound of 1 atom of iron with 1 of carbon, that is in the proportion by weight of 28 parts of the former with 6 of the latter, Berzelius believed in the existence of a compound of 2 atoms of carbon with 1 of iron, and also of 1 with 3 atoms of carbon to 2 of iron; Karsten and Ramelsberg hold to a compound of 4 atoms of the metal with one of the non-metal; Gurlt advocates the existence of a further compound of 8 of iron to 1 of carbon; and lastly, Von Mayrhofer thinks that definite substances of the formulæ Fe_4C, Fe_8C, Fe_9C, $Fe_{10}C$, and $Fe_{12}C$, may be present under different conditions.

With respect to graphitic carbon, our able metallurgist, Dr. Percy, in his justly celebrated work on iron and steel (p. 128), has the following statement, which, so far as the author knows, has not hitherto been contradicted. Speaking of the separation of graphite from pig iron, he says: "The fact of graphitic carbon being left by the solvent action of acids is certain evidence that this carbon was not present in the solidified metal, at least in a certain degree, in chemical combination with the iron. With regard to any distinct flakes of graphite which may be separated, there can be no reasonable doubt, though according to my experience, even they retain iron in some form or other, which is difficult to dissolve out completely. Moreover, when we carefully inspect the fractured surface of a piece of even highly graphitic iron, every part presents more or less of a graphitic lustre, yet not a trace of graphite can be detached by the point of a pen-knife."

It was this latter statement which led to the following investigation, the details of which, the author thought, could not be placed before a more fitting audience than the members of the Iron and Steel Institute. The methods of analysis followed, in order to elucidate the condition of carbon and silicon, have opened a fresh field of research, which will be alluded to in its place, and which it is hoped may lead to further and more important results.

But if the practical bearing of the investigation be not at present apparent, the author hopes his contribution may not be unacceptable to the members of the Iron and Steel Institute, as he believes the day has gone by for practice alone to reign supreme, and that rapid progress in manufacturing industry is only to be obtained when theory and practice go hand in hand.

There is no subject requiring more study than the chemistry of iron and steel, for every step in their manufacture involves a chemical problem, and the author cannot let the present opportunity pass without suggesting the desirability of this institution affording substantial aid in the matter, by the establishment of a laboratory for research. The British Association are doing something; but what is now suggested is the appointment of a chemist who should be in communication with the great body of scientific ironmasters throughout the country, and

be able to verify results, not by mere laboratory experiments, but by actual trials on a manufacturing scale.

The incorrectness of the statements respecting the separation of graphite from crystals of iron, became evident from the examination of some largely crystallized pig iron, which, having run over the tymp, had cooled slowly in a tub of slag. It was noticed that, in this case, the graphite could be separated from the faces of the crystals, not merely by the point of a penknife, but even by the finger-nail; and that having once detached the scale of graphite, the surface beneath was metallic iron. On exposure to a damp atmosphere, it was found that the metal became rusted below the scales of graphite, which then fell off. Continuing the observation, it was found that the same separation of graphite could be obtained from the faces of the crystals of Bessemer pig, and that the smallest crystal of gray iron was coated with its layer of graphite, which by appropriate means could be easily removed.

This being the case, it was at once seen, that by carefully removing these graphitic scales, we ought to be able to settle the question whether they were pure carbon, or a compound of carbon with iron, silicon, etc. It need scarcely be stated that the separation of a sufficient quantity of these scales for an analysis, is a tedious occupation, and that even with the greatest care it is almost impossible to prevent fine particles of iron, dust, etc., from contaminating them. By a little trouble, however, .0345 grammes of these scales were removed from the facets of crystals of compact gray iron. These were burnt in a stream of oxygen, when there was left a residue weighing only .0015 grammes, consisting mainly of a few microscopic particles of sand with the merest trace of red oxide of iron, resulting no doubt from the oxidation of the foreign particles of metal with which the graphite was contaminated. The carbonic acid found weighed .104 grammes, which is equivalent to .0283 grammes pure carbon; so that, even if the incombustible residue had been all peroxide of iron, there must at least have been 126 atoms of carbon to 1 of iron.

As the graphite could be thus easily removed from the crystals of pig iron, it was thought that other mechanical processes might be applied for its separation, and that the magnetic property of iron might also be made available. Some graphitic pig was therefore pounded in a steel mortar, to coarse particles, which, by their attrition, rubbed off the scales of graphite from the crystalline facets. The iron was removed by a magnet, and the graphite left behind. But here it was still more difficult to remove the last traces of metal; .1045 grammes of the graphite, after combustion, left a residue weighing .012 grammes, consisting of .008 oxide of iron, and .004 sand, silica, etc. As the Fe_2O_3 would be formed from .0056 grammes iron, and .0024 grammes oxygen absorbed, this latter weight must be added to the loss by combustion, thus making the total graphite burnt .0949 grammes. The carbonic acid found weighed .3505 grammes = .0955 grammes pure carbon, so that even here there was 17 times as much carbon as iron, or 46 atoms metal to one of the non-metal.

Lastly, .1415 grammes of kish, purified with hydrochloric and hydrofluoric acids, gave .518 grammes carbonic acid, equal to .14154 grammes pure carbon, and left no residue that could be weighed.

These results, we think, are sufficient to prove that scales of graphite can be removed from compact gray iron, and that these scales consist of pure carbon, for it is morally certain that the traces of iron found with them were simply accidental, and in no way combined with the carbon.

Graphite being much more friable than metallic iron, it was believed that it would be reduced to finer powder than the metal, in the process of drilling. Some gray Bessemer pig was therefore reduced to borings, and these were sifted through a very fine silk sieve. The original pig, coarse part, and fine portion which passed through the sieve, were analyzed separately, with the following results:

Total Carbon per cent. in 3 *Trials on different Pigs.*

	Original Pig.	Coarse part of Borings.	Fine part which passed through the Sieve.
(1.)	3.008	2.559	7.605
(2.)	3.331	—	9.214
(3.)	4.071	—	9.288

Again, graphite being so much lighter than iron, recourse was had to specific gravity as a means of separation. Two makes of iron were employed, viz.:—a

Middlesbrough gray forge pig, and ordinary Bessemer pig. The borings from each were divided into two portions, one half being sifted as above, and the other part separated by agitating with distilled water, and pouring off the lighter portions for analysis. These several products were completely analyzed, with the results recorded at the end of the paper. The carbon per cent. found in each case was :

		Original Pig.		Fine part separated by sieve.		Light part separated by specific gravity.
(1.)	Bessemer Pig	Graphite	3.341	9.11		28.48 per cent.
		Combined Carbon	—	—		
(2.)	" "	Graphite	3.190	7.79		21.274 "
		Combined Carbon	.2	.17		
(3.)	Middlesbrough Forge Pig	Graphite	2.650	7.015		41.329 "
		Combined Carbon	.35	.30		

These results show clearly that in gray pig iron the carbon exists in two states, and that the free, or graphitic carbon can be more or less separated by mechanical means, while the so called "combined carbon" decreases in the separated portions in the same ratio as the residual iron.

In spiegeleisen, refined metal, white pig, steel, and wrought iron, almost the whole of the carbon exists in combination, very little graphite being present; but the amount of graphite, as is well known, depends to some extent upon the rate of cooling of the fluid iron. Thus, if even gray Bessemer pig be cast in chill moulds the outer portions will be white and "case hardened," and, as a proof that there is less graphite in this than in the central gray part, the following analyses of a piece of bad forge pig may be cited. It will be seen that the white portion contains .25 per cent. less graphite than the

gray, although the total carbon was the same in each case. The piece of iron had the above appearance on fracture, and was drilled for analysis at the points marked ⊙

		Composition of White part.			Composition of Gray part.
Iron		92.240			92.150
Carbon	Graphite .850	2.573	Graphite 1.100		2.584
	Combined. 1.723		Combined 1.484		
Silicon	1st estimation. 3.978	3.972	1st estimation 4.001		3.989
	2d " 3.966		2d " 3.978		
Sulphur		.855			.875
Phosphorus		.702			.731
Manganese		.216			.234
Other Metals		Absent			Absent
		100.058			100.063

The largest amounts of graphitic carbon are contained in gray Bessemer pig; and of combined carbon in spiegeleisen, this alloy of iron and manganese having the property of retaining carbon in "combination" to a greater extent than iron alone. Some old analyses have been published, in which the total carbon in different classes of iron is shown as high as 6 per cent.; but in some hundreds of analyses of all brands of iron that have been made by the author, he has never, in a single case, found the carbon to reach 5 per cent., and this he thinks will be corroborated by all who have made analyses with our modern improved means of research.

From the experiments of our Vice-President, Mr. I. L. Bell, it would appear that some of this carbon is taken up by the ore during the process of reduction; but it is commonly supposed that the greater portion is taken up after complete reduction, and that the great cause leading to high carbon in pig iron is long contact of the fused metal at a high temperature in contact with carbon. The nature of the slag has an important effect in determining the quantity of carbon, which appears to reach its maximum when the

blast is hottest, slag most basic, ores least silicious, and burden light.

Whether there is any definite chemical compound of carbon and iron, or, as Dr. Percy suggests, of carbon, iron, and manganese, there is, we think, no data to decide; but judging from the few experiments which have been made, we are inclined to believe that the absorption of carbon by iron is a case of that weak kind of chemical action termed solution, and that there is no definite chemical compound of the two elements. It appears more probable that iron dissolves carbon *per se*, and retains it more or less on solidifying, according to the quantity that has to be taken up, the proportion of manganese present, the rapidity with which cooling is effected, and the amounts of such other bodies as silicon, sulphur, phosphorus, etc., held by the iron. It is generally the case that solution of a solid takes place more freely the higher the temperature, and so it appears to be with iron and carbon. That the carbon retained in the iron from mere solution should so marvellously affect its nature, according to the quantity present, is no greater wonder than that the diffusion of a small quantity of a definite chemical compound, of any one of the formulæ proposed should do; and altogether it seems more simple, and in accordance with fact, to suppose that carbon is held in solution and not in chemical combination in the ordinary sense of the term. The properties of any other solvent are more or less altered by dissolving various substances in it. Water, for instance, dissolves varying quantities of common salt according to the temperature, and although it will take up a certain weight without altering its bulk, yet the specific gravity is increased, freezing point lowered, and in many respects it is different from pure water. Again, after it has been saturated with salt, it is still capable of dissolving other bodies, as, for instance, alum. No one, however, regards the union of water, salt, and alum, in this case, as a definite chemical compound. Why, then, should not the union of carbon with iron be regarded as a similar case of solution? The fact that the union remains on solidification has its parallel in the case of mercury, which dissolves tin, in varying proportions, and the union remains on solidification.

Silicon.—This element is invariably contained in pig iron, and the author has never yet met with a case of even steel or wrought iron, in which it was entirely absent, though in good Bessemer and tool steel it rarely exceeds 2 or 3 parts in 10,000 of iron. When present in Bessemer steel, to the extent of about $\frac{1}{10}$th per cent., or 1 part in 1,000, it has the effect of rendering the steel hard and brittle when cold. Its presence in iron is due to the reduction of silica, which takes place in the blast furnace; and the conditions favoring its passage into iron are high temperature, light burden, free silica in the charge, and deficiency of lime, alumina, and other bases in the slag. It is also sometimes stated that the quantity of silicon passing into the iron will depend upon the pressure of the blast, but this evidently resolves itself into a question of temperature, as the greater the pressure, within certain limits, the more intense will be the combustion.

In ordinary Bessemer pig, silicon occurs in quantities varying from 1 to 4 per cent.; while white pig iron may contain mere traces, and spiegeleisen seldom has more than a few tenths per cent. It gives considerable trouble to the puddler in removal, and occasions great loss of yield in the process. Hence the desirability of having forge pig as free as possible from silicon. In the Bessemer process, on the other hand, it serves a very useful purpose, as during the blow it is burnt or oxidized, with the evolution of much heat. But, as in puddling, it occasions considerable loss of iron, and provided a sufficient temperature can be obtained, the less silicon there is in the pig the better. As, however, carbon is never present in sufficient quantity to generate all the heat required in the process, it is only when the iron contains large amounts of manganese, that silicon can be dispensed with below about 2 per cent. In some Swedish and Styrian Bessemer pigs, containing about 3 per cent. manganese, the silicon is under 1 per cent., and yet the charge works very hot. When iron or steel is dissolved in mineral acids, the silicon is oxidized, and silica separates along with the graphite, in a gelatinous state; hence it is generally believed to have been in chemical combination with the iron. It is, however, an element similar in many respects to carbon. Thus carbon is known to exist

in at least 3 different states, viz.: crystallized as the diamond, in semi-crystalline condition as graphite, and in an amorphous state as charcoal, lampblack, etc. Silicon has also been obtained in a pulverulent or amorphous form, in a graphitic state, and in the adamantine (or diamond) crystallized condition. One would then naturally expect that it would be found in iron in the same state as carbon, and, indeed, this is the generally received opinion; but a careful examination of the proofs of its existence in the graphitoidal or free state, failed to satisfy the author that this was the case.

As silicon, like graphite, is non-magnetic, and of low specific gravity (2.49), it appeared to the author that if it existed in the free state, the methods which succeeded in separating graphite should also answer for the separation of silicon.

The following analyses, some of which are of very silicious pig, show that silicon cannot be separated in this way.

Amount of Silicon per cent. in

	1 Original Pig.	2 Coarse part.	3 Fine part separated by sieving.	4 Light portions separated by spec. gravity.
West Cumberland Bessemer Pig	2.419	2.477	2.380	
Dowlais Bessemer Pig	3.77	—	3.433	2.93
" "	3.849	—	3.639	3.158
Middlesbrough Pig	1.815	—	1.610	1.219

Thus we see that instead of the silicon increasing in the finer and lighter portions, as the graphite did, the reverse is the case. It actually decreases, and in the same proportion as the carbon increases; in fact it remains with the metallic iron just as the "combined" carbon does, so that the coarse part, after removing some graphite, contains an increased proportion of iron and silicon, while the finer portion contains a less per cent. of these elements. It appears, then, that it must have been in combination or solution in the iron, and that it is, at least, an exceptional case, if it is found in the free state.

It may be well here to allude to those cases in which silicon has been stated to have occurred free. The most important instance is that of Richter, of Leoben, who asserted that he had found silicon in defined crystals in pig iron; but the editors of "Kerl's Metallurgy" suggest that this "may have been a compound of silicon and iron, as a small amount of iron was found in it." Percy states that the late M. Henry believed he had discovered crystallized silicon among the scales of graphite from pig iron, and that he himself regarded the evolution of gas like hydrogen, which took place on putting some graphitic scales (obtained from one of the Dowlais furnaces as "kish") into molten potash, as most probably caused by the presence of free silicon.

The balance of evidence, then, appears to favor the theory that silicon is dissolved or (to borrow a word which perhaps more nearly expresses the state of combination) "occluded" in the iron in the same way as the carbon, but that the solvent power of the metal is so much greater for silicon than for carbon, that it is quite a rare thing even if it ever occurs, for silicon to separate in a free state from the iron.

This greater solvent power for silicon is fully proved by the fact that carbon never exists to a much greater extent than 5 per cent., whereas Scotch pig iron has been found with as much as 8 per cent. silicon, and Dr. Percy succeeded in obtaining a melted metallic product with 18.77 per cent. silicon by reducing sulphide of iron in contact with sand and charcoal; indeed it seems to be an easy matter to obtain a compound of iron with 10, 12, or 15 per cent. silicon. The author has not yet had an opportunity of applying the methods of mechanical separation to such products as these, but hopes to do so before long. It is generally supposed that the absorption of much silicon tends to set free carbon in the graphitic state. Pig iron containing much silicon melts readily, and is generally weak and easily broken; and, indeed, from long observation, the author can generally tell whether the Bessemer pig contains high or low silicon, by the facility with which the workmen break the pigs by dropping them on the △ iron.

No direct experiments have been made on the tensile strength of pig iron containing a constancy of other elements with varying quantities of silicon, but Fairbairn and others have ascertained the strength of particular brands of pig iron after several successive meltings, and have found that the metal generally increases in strength up to a certain point, and then each fusion reduces the resistance to rupture. Now, the author believes the explanation of this to be, that at each successive melting, the silicon, and perhaps to a slight extent, the carbon, decreases; but the iron gradually takes up sulphur and phosphorus from the fuel, and the deterioration due to these elements more than counterbalances the increased strength due to diminished silicon and carbon. This theory seems to be borne out by the specific gravity of the samples, which shows a gradual increase throughout.

According to Price and Nicholson, Calvert and Johnson, and Lan, nearly the whole of the silicon is removed in the process of puddling before the carbon is touched, but it by no means follows that, because it is easily oxidized, it has no injurious effect in delaying the process; indeed the author has very positive evidence that the reverse is the case.

In the Welsh refinery process, and also in the Heaton process of conversion, the same rapid removal of silicon takes place, as is seen in the following analysis:

	White Pig Iron.			Refined Metal made from former.
Iron		94.006		96.485
Carbon	Graphite 8	2.597		2.428
	Combined 1.797			
Silicon	1.918	1.908	.126	.128
	1.899		.130	
Sulphur		.553		.144
Phosphorus		.886		.815
Manganese		.050		Trace.
		100.000		100.000

Conversion by Nitrate of Soda Process.

	Mix Pig used.				Samples of crude converter metal made from preceding.			
	A.		B.		Hard piece.		Soft piece.	
Iron	(Direct)	93.997	(By diff.)	94.030	(Direct)	97.435	(By diff.)	98.486
Carbon	2.36 graph. .446 com.	2.806	.....	2.570	(All com.)	2.061	.....	1.098
Silicon	2 011	2.006	1.946	1.959	.....	.014	.....	Trace
	2.002		1.973					
Sulphur		.034	.....	Trace	.....	Trace	.....	Trace
Phosphorus		.446	.....	.558	.....	.489	.....	.344
Manganese		.648	.....	.885	.....	.064	.....	.072
		99.937		100 000		100.063		100.000

It was formerly supposed that in the Bessemer process the whole of the silicon was removed before the carbon was touched; but, as was stated by Mr. C. P. Sandberg (in a paper communicated by him to the Institute of Civil Engineers), from experiments by the author of this paper, it has been found that this is not the case. These two elements are both rapidly oxidized from the commencement of the blow, but the silicon being more easily attacked, disappears quickest. If, however, the pig iron contains an excess of silicon, and but little carbon, this latter may be all burnt out, and the body of flame disappear, so that the workmen may suppose the metal to be fully blown, while it still contains sufficient silicon to render the steel very brittle. This is, of course, a very exceptional circumstance, and can never take place if the "charge" is properly regulated; but that it does sometimes occur is fully proved from the following analyses of underblown steel, which, it is right to state, are the only instances of the kind that have come under the author's observation during the course of his extended experience at the Dowlais Works. He has been informed, however, by other metallurgists, that they have occasionally met with similar instances. An analysis of "Iron

Skull," from a Bessemer reverberatory melting furnace, exhibits the same phenomenon.

Lest it should be supposed that the brittleness of the steel here mentioned, is in any way due to the presence of other elements, the analysis of ordinary Dowlais steel rails is given, which, it is well known, are seldom broken by the fall of the ton-monkey from a height of 20 to 30 ft.

Underblown Steel, containing High Silicon.	
No. 1. Carbon	.445
Silicon	.814
No. 2. Carbon	.515
Silicon	.270

Iron Skull from Melting Furnace.	
Iron	98.348
Carbon	.729
Silicon	.665
Sulphur	.110
Phosphorus	Trace
Manganese	Trace
	99.852

	Brittle Steel, with High Silicon.	Good Steel.
Iron	98.120	98.831
Carbon	.550	.490
Silicon	.634, .644, .644 — .640	.009
Sulphur	.069, .066 — .067	.033
Phosphorus	.038	.036
Manganese	.554	.576
Copper	.031	.025
	100.000	100.000

The gradual oxidation of carbon along with the silicon from the commencement, is shown by the following analyses of metal taken during the blow. These statements regarding the removal of carbon and retention of silicon have been corroborated by Professor Tunner, and also by a Swedish matallurgist of repute.

Analyses of Bessemer Metal during the "Blow" of the Pig used, and Steel Produced.

	Melted Charge of Pig.	No. 1. Sample taken at the end of first stage, 6 min. from start.	No. 2. Taken 9 min. from start.	No. 3. Taken at finish before adding spiegel. 13 min. from start.	Steel Borings from an ingot.	Steel Borings from rail crop ends.
Iron	94.682	97.245				
Carbon	Graph. 2.07, Com. 1.20 — *a* 3.218	*b* 2.17	1.55	.097	.566	.519
Silicon	1.964, 1.941 — 1.952	.792, .798 — .795	.635, .635 — .635	.020	.030	.033
Sulphur	.014	Trace	Trace	Trace	Trace	Trace
Phosphorus	.050, .047 — .048	.055, .048 — .051	.064	.067	.055	.053
Manganese	.086	Trace	Trace	Trace	.309	.309
Copper					.039	.039

Wrought iron is frequently to be met with, which is not at all brittle, and yet contains enough silicon to have produced decided cold shortness in steel. The author believes that this apparent inertness of silicon is in part at least due to the fact that in any product like steel which has been molten, the whole of the silicon present must be in the combined or "occluded" condition, while in the case of wrought iron which has been in a pasty state, much of the silicon shown in analyses really occurs as silica in the interposed slag, which does not materially affect the strength of the metal, but renders its wearing properties vastly inferior to those of steel. The author has recently met with a sample of iron, containing a large percentage of this interposed slag, and found the composition in this case to be :

Silicon ..... .155
Phosphorus ..... .189 } in 1.069 slag.
Iron ..... .231

which, if calculated to the states in which these bodies probably existed, would be :

Silica ..... .333 = 31.25 per cent.
Phosphoric acid ... .433 = 40.505 " "
Protoxide of iron .. .297 = 27.843 " "

It is this interposed slag which renders

a The total carbon is estimated by direct combustion, the graphite and combined by separate experiments.
b All combined.

built up or "piled" rails so liable to be crushed, as it prevents perfect union or welding of the crystals of iron.

In like manner very fair wrought iron contains amounts of sulphur and phosphorus that would be fatal to steel, and the same explanation may probably be applied here.

There does appear, however, to be some difference in the modes of existence of sulphur and phosphorus in pig iron, for in completing the analyses of the various products obtained by mechanical separation as explained above, the author was struck with the remarkable and unexpected fact, that the finer portions which contained most graphite, contained also an increased per cent. sulphur, while the phosphorus decreased in about the same ratio as the iron. The manganese also appears to accompany the sulphur to some extent.

It might possibly be thought that this difference arose from errors of analysis, but it is too great to be thus accounted for even with the most careless manipulation, while the author need scarcely state that every possible precaution to guard against error has been taken, and not only have almost all the experiments been made in duplicate, often in triplicate, and when possible by two different methods, but the re-agents were carefully tested for purity, and the precipitates proved to be pure and what they professed to be.

This part of the subject requires further investigation, and the author hopes at some future time to communicate the results of additional experiments. There is no doubt that the methods of mechanical separation adopted by the author for the investigation of the condition of carbon and the silicon, will prove effectual aids to the ultimate analysis of iron, and a valuable supplement to ordinary methods of research.

Complete Analyses of Samples of Pig Iron, after Mechanical Separation of their Constituents.

MIDDLESBROUGH GRAY FORGE PIG.

	A Original Pig Iron.		B Fine part, which passed through silk sieve, about No. 130.		C Light portions, separated by specific gravity (by washing).	D Lightest portions separated by specific gravity (by wash).
Iron	.....		.....		57.735	54.733
Carbon	Graphite {2.69 direct / 2.61 × HF} 3.000 Combined .35		Graphite {7.05 / 6.98} 7.315 Combined .3		Graphite 37.623	Graphite 41.044
Silicon	1.81 / 1.82	1.815	1.60 / 1.62	1.610	1.240	1.211
Sulphur	068 by Aq. Regia 073 by H Cl & K ClO$_3$	.070	.205 / .173	.189	.760	.644
Phosphorus	1.79 / 1.77	1.780	1.81 / 1.74	1.770	1.345	1.344
Manganese	.504 / .490	.497		.482	1.383	.875
Calcium		Absent		Absent	Absent	Absent

DOWLAIS BESSEMER PIG—Similarly Treated.

Iron	.....		.....		86.101	75.278
Carbon	Graphite {3.04 / 2.94} 3.19 Combined .2		Graphite {7.64 / 7.60} 7.790 Combined .17		Graphite 10.111	Graphite 21.274
Silicon	.3826 / .3873	3.849	3.658 / 3.261	3.639	3.443	3.131 / 3.185 3.158
Sulphur		.011	.035 / .038	.036	.054	.068 / .065 .066
Phosphorus	.081 / .076	.078	.072 / .069	.070	.070	.058 / .058 .058
Manganese		.244		.230	.216	.164

Coarse part of Borings remaining after the separation of C and D.

MIDDLESBROUGH PIG.

Iron	94.200
Graphite	1 884
Silicon	1.885
Sulphur	.060
Phosphorus	1.773
Manganese	.490

DOWLAIS BESSEMER PIG.

Iron	93.708
Graphite	2.072
Silicon	3.880
Sulphur	.011
Phosphorus	.079
Manganese	.240

It should be mentioned that of 712.8 grammes of fine borings of the Middlesbrough pig, 68.8 grammes or 9.65 per cent. passed through the sieve and formed the part marked B in analysis, while of 2,551 grammes of Dowlais pig 194 were passed through the sieve. In the case of the light portions separated from the remaining halves of the borings by specific gravity, only a very small proportion of the whole was obtained which was not estimated.

In concluding this paper, the author begs to record his appreciation of the efficient services rendered in the above investigation by his assistant, Mr. W. Jenkins.

At the close of the reading, the following remarks were offered in reply:

Mr. I. Lowthian Bell: The able and highly interesting paper just read requires for its proper appreciation some previous consideration, and hence we must all admit how useful it will be for members who may have anything to communicate to the Institute to comply with the recommendation of the Council, and allow their respective papers to be printed and circulated previous to the day of meeting.

I entirely agree in Mr. Snelus's dissent from the conclusion arrived at by Dr. Percy, in respect to the separation of graphite from the faces of crystals in pig iron; for I do not remember ever having failed in being able to detect this substance in the manner named by the reader of the paper.

I was glad to notice the applause which followed Mr. Snelus's remarks on the propriety of establishing a chemical laboratory in connection with the Institute; not because I am very sanguine of its practicability in our own case, but because I see in your approbation a recognition of the importance you attach to chemical science in connection with your profession as iron manufacturers.

I would just observe, in allusion to what occurs in the paper we have just heard, respecting my own labors in connection with carbon deposition in iron ore during the process of smelting, that I considered I had proved the dissociation of carbonic oxide is effected at a temperture much lower than that at which it has been hitherto supposed to take place, and that complete reduction of the oxide of iron is by no means essential for its occurrence. I do not, however, pretend to say that there is any combination of the iron and the carbon at this low temperature, which probably does not happen until the hearth of the furnace is reached. I would remark, in reference to Mr. Snelus's supposition that silicon is perhaps dissolved or "occluded" in larger quantities by iron than is carbon, that I have observed that silicon is certainly found occasionally in pig iron more abundantly than even happens with carbon; but I do not agree with him that it never separates from the iron something in the manner of carbon. I have, upon more occasions than one, found the exterior of the "pigs," and in particular cavities in the sows or runners, coated with fibrous silica of such a physical aspect as to permit no other explanation than that it arose from silicon extracted from the iron in cooling, and oxidized as it came in contact with the atmosphere.

Of the retarding effect of silicon in puddling, I have had frequent experience. I recollect receiving a parcel of glazed or silvery pig, rich in silicon, which resisted all attempts either of refining or puddling, and was only got rid of by using infinitesimally small quantities with other iron.

Mr. Bessemer: I wish to make a few remarks as to the presence of silicon in steel. A very general opinion prevails in the trade (and it is a correct opinion when we speak of large quantities) that silicon is very injurious to the quality of iron, and that by getting entirely rid of it you make iron of a superior quality. This, however, is not the case with cast steel. In proof of which I call attention to the old steel process, as carried on at Sheffield, where the highest qualities of iron are used—some of the brands of Swedish

iron show not a trace of silicon. When iron of this high quality is put into the crucible, and melted with a sufficient quantity of carbon to produce steel, one would suppose, from the absence of silicon, that we should have the finest quality of steel. But it is not so, when heat sufficient only for fusion is used; for if the ingot be then poured it will not work soundly under the hammer. The old trade term for steel in this condition is, "not well melted," signifying that it has not been long enough in the furnace, although fusion is complete. In order to ascertain the cause of this defect in steel, I have made the following experiment: I have taken Danamora iron, and cut up the bar into small pieces, and put them in equal quantities into two separate crucibles, and placed them side by side in the same furnace. The heat and all other conditions were precisely the same. When complete fusion had taken place, one of the crucibles was drawn and the ingot cast. The second crucible was left in the furnace for two hours longer, and the heat considerably increased. The second crucible was then poured out; the result was that the first ingot went to pieces under the hammer, and in the second instance it worked admirably, more like a piece of copper than steel. It would thus appear that the continued heat had taken out something from the metal, or had been the cause of some additions thereto, for it could not be the iron, which was the same in both cases; but analysis proves the fact that there was silicon in the second ingot and not in the first. The carbon in the crucible had converted the wrought iron into steel, and had also reduced some of the silica, always present in the form of sand at the bottom of the pit; and to that accidental circumstance the Sheffield manufacturer owes the production of his best steel. In making the crucible, it is difficult to get the core into its proper place, and it has been found necessary to make a hole in the bottom of it for that purpose; and when the crucible is placed in the furnace a handful of sand is thrown into it to stop the aperture. This use of sand has really been the unknown secret of making the best quality of steel; for if you keep the steel in the furnace at a high temperature, enough silica is always reduced by the carbon, and in the metallic form is alloyed with the iron. I offer this fact as a proof that the presence of silica (which is so injurious in large quantities) is necessary in small quantities in steel. Indeed, I have not had a single analysis of the best quality of Sheffield steel that did not contain silicon.

The noble President: Before we dismiss Mr. Snelus's paper, he wishes to make some remarks in reply.

Mr. Snelus: I wish to make one or two remarks as to what Mr. Bell has said with regard to the deposition of carbon in ore during the process of reduction. I have made a few experiments in that direction, and I think the deposition of carbon in ore, during the process of reduction, is due to the action of the fine particles upon the gas at high temperatures. For this reason, I took pure sand—although in this case I used coal gas, and the conditions were slightly different from those of Mr. Bell—but I took fine angular pieces of sand, and heated them in the tube, through which I passed coal gas, and on the angular particles carbon was deposited, while none was deposited on the smooth surface of the porcelain tube. So that I think the deposition of carbon in ore at a low temperature is due to other causes than the chemical action of the reduced iron. I find, as Mr. Bell stated, that reduced ore generally contains more or less carbonaceous matter, but it is not in a state of chemical combination. You are probably acquainted with the color test of Eggertz, for combined carbon. Now, I have taken iron ore, which I had perfectly reduced at low temperature, and on dissolving it in nitric acid, as in the Eggertz method, no color was obtained, but a residue of free carbon was left, showing that this carbon was not in chemical combination with the iron. I have not a word to say as to Mr. Bessemer's remarks, except that in my experience I have never known an instance, as stated in the paper, in which the very finest qualities of iron or steel were perfectly free from silicon. There is an example of Mr. Bessemer's own steel, which contains 0.009 per cent.; in fact, so small is the quantity that we were scarcely able to estimate it, but we did estimate it, and there is the actual quantity. And I have never found a case in which, on dissolving iron or steel in large quantities, you did not

see silica in solution floating about, proving that the iron contained silicon. With regard to the separation of free silica from iron, the instance given by Mr. Bell shows that that was an exceptional circumstance, and I am not sure that it was separated from the pig iron as silicon ; or whether the form in which Mr. Bell found it as free silica, was not due to other causes. It is well known that free silica is found in blast furnaces frequently, and that has been pointed to as a proof that silicon existed in pig iron in a free state. But I do not see the connection, because I think silica may be found in a free state in blast furnaces without ever having entered into the composition of pig iron.

HYDRAULIC TRAIN LIFTS.

From "Engineering."

The terminal points of the railways from Aix-la-Chapelle to Homberg, and from Oberhausen to Ruhort, are situated on the right and left branches of the Rhine, by which river they are separated. So early as 1847 propositions were made for the construction of works to join the two lines, and in 1852, by the joint efforts of the executives of the railways, a steam ferry was established, with satisfactory results. The junctions between the ferry boats and the stations had been made in the ordinary way, with inclined planes of 1 in 10, and the shunting of the carriages and wagons between the boats and the stations was done by shunting engines, which, however, did not travel on the inclined planes, but moved the trains by means of wire ropes. This system, however, was found to possess considerable disadvantages, and after various plans had been tried, with more or less success, it was finally determined to abandon the inclined plane altogether, and substitute for it between the boats and the station level the hydraulic lift.

The ferry boat, a side-wheel steamer of 200 horse-power, with two oscillating cylinders of 46.4 in. in diameter, and 37 in. stroke, was built by Messrs. Jacobi & Co., of Sterkrade; it has a flat deck 171 ft. 6 in. long, and 26 ft. 9 in. wide amidships. It carries 3 parallel lines of rails, which give accommodation for about 20 10-ton goods wagons. The depth of the boat is about 9 ft., the draught of water when empty is 36 in., and when loaded 48 in. Steering apparatus is provided at both ends, and the diameter of the paddle wheels is 14 ft. 5 in.

The lifts are placed on each side of the river, and the platform for lowering or raising the wagons, moves vertically in the tower as shown. This platform is framed upon iron girders, and carries 3 lines of rail, corresponding to those on the ferry boat. The pairs of rails at the sides are 24 ft. 8 in. long, but the central pair is extended in the direction of the station to a length of 36 ft. These latter are employed for the long 6-wheeled trucks, and the former for the shorter 4-wheeled trucks. The platform moves in the lower part of the tower upon girders bolted to timber beams built into the brickwork. Of course the height of lift varies according to the level of the water; the platform can be lowered to the lowest level of the water, whilst its highest position is fixed by projecting beams. The longest stroke or lift of the platform is 27 ft. 6 in., but the height most commonly required varies between 13 ft. and 16 ft. The lower part of the lift tower is open on the side towards the water, and the ferry boat enters this opening, being kept in position by guide and fender piles, and being protected from injury by suitable buffers.

When the platform is fully lowered it rests upon the end of the boat, to which it is connected by means of a coupling apparatus, and the trucks are then shifted from the boat to the platform, on which they are lifted to the station level.

The platform is lifted by means of hydraulic presses, which are placed in the upper part of the tower. The main lifting cylinder is 29.84 ft. in length, with metal 2 in. thick. This is placed in the centre of the building on wrought-iron cross girders, about 19 ft. above the station level. A plunger, 29.84 ft. long and 12 in. in diameter, works within the cylinder, and to the upper end of the piston is secured a cross-

head to which are attached, first, the guide blocks, which work against rails which are supported within the tower by timber framings; second, the 2 chains carrying the platform; third, 2 chains which are taken up to the top of the tower, and, passing over pulleys, support counterpoises weighing 25 tons collectively. These are employed to balance the dead weight of the piston and the platform. Fourth, a chain which passes over rollers, and is connected at its other end with a second and smaller lifting cylinder, 7.48 in. in diameter, and with a stroke equal to half that of the main cylinder. The chain before spoken of is not attached direct to the piston, but passes over a pulley upon it, and is then connected to the cylinder in such a way, that not only half the pressure, but the full stroke of the piston is transferred to the chains. The small cylinder is generally employed only for lifting the empty platform; but both cylinders may be employed together in case any unusually heavy load has to be lifted.

The pumps supplying the water are not placed in the tower, but in a separate engine-house at the side of the station. This engine-house contains a horizontal high-pressure engine of 30-horse power, with 2 cylinders of 13.77 in. diameter. The piston-rods of these cylinders drive direct the double-acting pumps for the hydraulic presses in the lifting tower. The water, however, is not pumped direct into the water tower, but passes into an accumulator, provided with a plunger piston, from which is suspended a counterpoise consisting of an iron box filled with kentledge. The piston is 19.68 ft. long and 16.53 in. in diameter, and it exerts a pressure upon the water of 57.6 tons, or 650 lbs. per sq. in. The effective cubic contents of the accumulator is equal to the sum of the cubic contents of the 2 cylinders in the water tower. The loaded box of the accumulator piston is provided with brackets and chains, by which the safety valve is opened, and the throttle of the steam pipe closed, so soon as the piston has reversed its highest position. The engine then works very slowly without producing any further lift of the loaded box, but employs again its full power as soon as a portion of the water in the accumulator has been consumed. Additional pumps are provided for pumping from the well into a tank and for feeding the boilers. The pressure main passes through the lower part of the tower into a receiver with valves, from which the water is distributed as required. The receiver is made of cast iron, and consists of tubular chambers, from which the water is carried off by 4 pipes, namely: 1st, the pressure main; 2d, the waste pipe leading to a small reservoir under the roof of the tower, and thence into the main reservoir of the engine-house; 3d, the pipe to the main cylinder; and 4th, the pipe to the small cylinder. Each of these pipes is provided with separate valves, by means of which the required combinations are effected. There is in addition a self-acting safety-valve within the tank, which opens into the pressure main as soon as the downward motion of the platform produces in the lifting cylinder a greater pressure than exists in the main itself. Another valve, serving a similar purpose, is also placed between the distributing chamber and the main cylinder. Two other self-acting valves are also added for the purpose of filling the one cylinder with water not under pressure, while the other cylinder only is acting, so that empty spaces or vacuums are prevented.

The cost of constructing the ferry was £19,850, of which £7,011 were expended on the machinery, and £11,865 for the boat. After the work had been erected, and sufficient experience had been obtained as to its satisfactory working, a second boat was constructed and put to work. This boat, which cost £11,227, gives accommodation for 16 10-ton wagons, and is fitted with engines of 400-horse power.

The average work done by the ferry with 1 boat is 16 wagons per hour; the time for crossing the Rhine varies from 10 to 15 min., according to the level of the water; the lifting velocity of the heavily-loaded platform is between 17 and 18 ft. per min.

The greatest effective load that can be lifted is 31 tons, the pressure in the accumulator always 49 atmospheres, whatever the position of the loaded piston may be, and whether the lifting cylinders are at work or not. The pressure of the water in the lifting cylinder corresponds with the load

to be lifted; it varies between 11 and 39 atmospheres, for the unloaded platform, so that when loaded with 31 tons, if the platform is at the top of its lift, the pressure in the cylinder increases to 49 atmospheres.

ELASTICITY AND TENSILE STRENGTH OF WROUGHT IRON.*

By GEO. W. PLYMPTON.

Having occasion, a few years since, to test a large number of iron rods which were to be used in a Murphy-Whipple bridge, I found it convenient in some cases to extend the experiment so far as to determine the breaking strain, and also the highest tensile strain at which the elasticity remained unimpaired.

As the rods were designed for diagonal ties of a rectangular truss of 150 ft. span, the testing machine was of unusual dimensions. It consisted of a heavy framework formed of 2 pieces of pine 16 by 20 in., and 30 ft. in length. They were 18 in. apart. Heavy cross-pieces of oak at each end completed the framework or bed-piece.

The strains were applied by means of a screw 3 in. in diameter, working through a thick iron plate and one of the oak head pieces. The outer end of the screw was furnished with a ratchet-wheel, 12 in. in diameter, and a lever which worked on the extended screw as a fulcrum. A stout ratchet on the lever completed the movable outside portion at the head of the machine. Inside the head-piece, the screw terminated in a stout cast iron cross-head, in which it turned freely. The cross-head carried a pair of parallel flat bars, to which the rod under test was made fast. To facilitate the fastening, and to render the apparatus adjustable for testing rods of different lengths, the parallel bars were furnished with inch holes, 6 in. apart, exactly opposite in the 2 bars, and a sliding cross-head which could be firmly attached by pins at any pair of holes in the bars.

At the other end of the machine the strains were measured by a balance beam 10 ft. long. A 2 1-9 in. bolt, carried through the head-piece, was furnished with an eye on the inside end, and on the outside was (after being passed loosely through a thick iron plate which formed the end of the balance beam) forked so as to hold securely a steel block with a face at right angles to the axis of the rod; this face was made to bear upon a knife-edge when the machine was in operation.

The balance beam was constructed like a king-post truss, with an extra rod following the line of the inclined studs. At the end next the machine the plates above referred to were secured by bolts so as to form the extreme end of the beam. The plate had 2 blunt knife-edges, one on each side; the one towards the machine rested on a plate attached to the oak head-piece; the knife-edge on the other side, which was $\frac{1}{10}$ of a ft. higher, had for a bearing the steel block which received the strain of the rod under test.

To the extremity of the balance beam was hung a platform to receive weights. It will be seen that the tensile forces were therefore measured by a bent lever, whose arms were respectively $\frac{1}{10}$ of a ft. and 10 ft. The machine was designed by Mr. J. W. Murphy, of Philadelphia, and constructed under his direction.

The tests to which the great majority of the rods were subjected were made in accordance with the terms of the bridge contract, which required that the wrought iron rods should prove perfectly elastic under a strain somewhat greater than that to which they would be subjected when in place by the maximum load on the bridge.

As this computed maximum strain was supposed to be about $\frac{1}{4}$th of the ultimate strength, the tests were extended to $\frac{1}{3}$ or $\frac{2}{5}$ of the breaking strain. The rods, of course, extended under the strain; any rod that failed to recover its original length when the strain was released was condemned.

In order to verify our estimates of the ultimate strength, as well as to determine the limit of elasticity, an occasional rod was subjected to the proper tests. The results obtained under these conditions form the subject of this paper.

The measurements by which the extensions were determined were made with

* Paper read before the New York Society of Practical Engineering at the regular monthly meeting, April 26, 1871.

a rod 10 ft. in length, and its measure on the rod under strain was marked with a knife-blade. The extensions corresponding to this length were carefully measured by a finely divided scale.

Many of the rods subjected to the breaking test were prepared for the experiment in such a way as to bring to trial the different modes of fastening at the ends. Some of them, therefore, had threads cut on stub ends welded on, some had threads cut on the original rod slightly upset at the end, while others were furnished with a turned eye only. Many rods showing a high degree of elasticity in the sound portion broke at a comparatively low tensile strain in the thread or weld.

The results of these experiments, as deduced from the tables prepared at the time, may be briefly summed up as follows:

(1.) The breaking strain of wrought-iron rods of American manufacture varies from 45,000 to 57,000 lbs. per sq. in. of section. A few of professedly poorer quality parted at 40,000 to 42,000 lbs. per sq. in. The relative tensile strength was slightly greater in the smaller than in the larger rods.

(2.) The extension of a rod under a gradually increasing strain varies directly as the strain up to the limit of the elasticity of the rod; beyond this limit the extensions are in a much higher ratio than the increments of tensile force. An illustration of this is furnished by the first case in my tables. A $\frac{3}{4}$-in. rod of "Howard" iron under a strain of 11,000 lbs. per sq. in. extended $\frac{13}{1000}$ in. for 10 ft. in length; at 20,200 lbs. it had extended $\frac{22}{1000}$ in.; at 26,450 lbs. its extension was $\frac{29}{1000}$ in., and upon being relieved of strain recovered its length; at a strain of 41,600 lbs. its extension was 5 and $\frac{50}{1000}$ in.; upon being relieved of strain, it set with an extension of 5 and $\frac{23}{1000}$ in. The rod broke under a strain of 49,950 lbs.

(3.) The limit of elasticity under the circumstances which necessarily governed such a trial proved to be about $\frac{3}{5}$ths of the breaking strain; in no case lower than a half of it.

(4.) The amount of extension of the rod before reaching the limit of elasticity was in no case lower than $\frac{1}{1000}$ nor higher than $\frac{1}{100}$ of the length.

(5.) The amount of extension which iron exhibits before parting varies greatly in the different brands, and bears moreover no discovered relation to the elastic limit or ultimate strength.

(6.) Although among the rods broken both kinds of fracture (granular and fibrous) were exhibited, no peculiar advantage could be claimed for either at strains below the limit of elasticity. Those which in breaking showed a fibrous character extended by far the most before parting.

(7.) A rod strained beyond its limit of elasticity and then laid aside for a time, proved (in each of several cases) upon repeating the test to be a rod of lower limit of elasticity than at first.

(8.) As a matter of curiosity, it may be remarked that the permanent set of an *overstrained* rod proved in the several cases to be its greatest length, under strain, *minus* its extension before losing its perfect elasticity.

(9.) The usual factor of safety employed by engineers, viz., $\frac{1}{3}$th of the ultimate strength, is well within the elastic limit, and is perfectly safe for bridges and roofs. It is, moreover, safe to test such rods up to the amount of proper working load before using them in the structure.

(10.) Although many rods from old bridges were tested in this series, no support for the popular theory that iron deteriorated under use could be gathered from our experiments. It may be remarked here that the late John A. Roebling, whose experiments were in progress about the same time, drew the same conclusion after a series of experiments upon a very wide range of varieties of wrought iron and steel.

The limit of elasticity would undoubtedly have appeared lower if longer time could have been allowed between the separate additions to the strain; but after a careful consideration of the published experiments, both in this country and Europe, it is believed that the practical conclusions drawn from the above tests are substantially correct.

The Mount Cenis Tunnel is now nearly completed. The works on the Modane and St. Michael Railway are being pushed forward with the utmost possible activity.

THE APPLICATION OF STEAM TO CANALS.

By GEORGE EDWARD HARDING, C. E.

From the "Journal of the Society of Arts."

The immense capital invested in canal property, and the extended lines of inland navigation throughout the various districts of Great Britain, Northern Europe, and the United States of America, causes regret that, while so much has been done in past years to develop the trading interests of these countries, such extensive internal communications have been suffered to remain dormant, burdened by the same defective system of navigation which, once ample for the transportation of goods when the pack-horse and the country wagons were their only competitors, now is in most miserable contrast with the perfect system and dispatch that characterizes the management of the railways of the present day. The defects and delays in the transportation of goods *via* canal, not lessened by the private interests and conveniences of drivers, boatmen, and others engaged in their traffic, where heavy boats are dragged from one destination to another at the slowest possible speed by the wretched beasts that lean for support against the towing lines, point to the necessity of a radical change, to redeem them from the position to which they have sunk in the competition of the day.

Commencing with the early history of canals, we propose to present some of the more prominent experiments which have been designed to improve the construction of vessels adapted to inland navigation, and the application to them of mechanical means of propulsion.

Save that the large drains cut by the early churchmen in the Cambridge fens seem to have been employed for purposes of occasional inland navigation as early as the fifteenth century, the great commercial republic of Holland may safely claim centuries of European priority in the construction of a system of artificial water-roads which the industry of its people had turned to a good account of prosperity and power. France, Sweden, and even semi-barbarous Russia, had also taken the lead in this respect long before England had entered upon her career of canal construction, though in Egypt, long before the invasion of Great Britain by the Gauls, and in China, at a still earlier date, we know of their introduction, yet their origin is undoubtedly merged in the system of irrigation which, for unknown ages, has been pursued in those countries. Certain authorities have claimed that during the invasion of England by the Romans the works executed by them in the Fen districts were also used for navigable purposes, but of this we have no tangible proofs. In 1623, however, we find from Parliamentary records that Sir Hugh Myddelton was engaged in considering a bill "For the making of the River of Thames navigable to Oxford;" while, 23 years later, one Francis Mathew addresses to Cromwell and his Parliament a paper upon the immense advantages of opening up a water communication between London and Bristol, which purposed making the rivers Isis and Aire navigable to their sources, with a short canal to connect their heads across the intervening country; but, for Mathew's time, a scheme for the construction of 3 miles of canal, even by the State, was far too daring, and a century elapses before a canal is made in England.

Andrew Yarrington, gentleman, next publishes, in 1677, a curious book, entitled "England's Improvements by Sea and Land, to out-do the Dutch without fighting, to pay debts without moneys, to set at work all the poor of England with the growth of our own land," in which he strongly contrasts the prosperous energy of the Dutch, especially regarding their inland water communicaton, with the passive indifference of Englishmen to the immense advantages in their numerous streams and rivers, lying dormant at their very doors, wanting only improvement in their existing beds, with proper connection, to develop the trade and prosperity of the country.

To the lack of capital at this time can be traced the secret of the little progress of the internal communication of the country, and though Parliament liberally granted permission for river improvements, yet, from the want of money, few were attempted, or, if commenced, failed from the same cause.

About the beginning of the eighteenth century, the opening of the navigation of the rivers Aire and Calder gave a great impetus to the trade of that portion of Yorkshire, and stimulated the demand for improvements in inland navigation, and we find its first fruits in an Act of 1720, to make navigable the Mersey and Irwell, from Liverpool to Manchester; and, at about the same time, Acts for the improvement of the Weaver, Douglass, and the Sankey navigations were granted, and, what was more to the purpose, the works carried out. Again, in 1717, as a reference to the pamphlets of the British Museum will show, Dr. Thomas Congreve published some views, headed "A Scheme and Proposal for making a Navigable Communication between the rivers Trent and Severn, in the County of Stafford," which paper project slumbered for 40 years, till, in 1755, a survey was made for this very line of canal, under the auspices of the "Liverpool Corporation of Merchants," which line proceeded by Chester to Stafford, Derby, and Nottingham; and from Brindley's "Note-book" we find that he executed a fresh survey over the same ground in the years 1759–60, but at the expense of Earl Gower and Lord Anson.

Thus, it is not till the middle of the last century that English enterprise was fairly awakened to the necessity of a system of artificial canals; and directly traceable to the execution and extension of these earlier river improvements can we date the present system of internal communication, which has conduced so largely to the industrial prosperity of the English nation; and to the consequent increase of British manufactures and their distribution do all countries owe many of their indispensable comforts of life.

Apart from the deductions that would naturally follow from the river improvements, it is well known that, in 1755, the deepening and widening of the Sankey brook, tributary to the Mersey, with the application of a floodgate for retaining tide water, gave the hint which culminated in the construction of the well-known Bridgewater-canal, under James Brindley; but the rapidity of extension was afterwards such, that, between the years 1760 and 1803, no less than 2,295 miles of canal were opened. From the exceedingly interesting history of this Society, written by Mr. Davenport, we learn that the gold medal of the Society of Arts was awarded, in 1800, to the Duke of Bridgewater, as the father of inland navigation, and for his general exertions in promoting the interests of inland water carriage, since which date there seems to be no note of special award to the workers in this particular field of the economy of nations. Indeed, since the adoption of canals, except in the substitution of horses for men at the towing-lines, and some improvements effected in the manner of passing boats from one level to another, they may be truly said to have remained stationary in the general march of improvement, and, unlike all other arts, have partaken of none of the benefits arising from the increase of mechanical science. It is in the hope of calling attention to the fact, that by the exercise of a tithe of the mechanical ingenuity which has been expended on railways, canals might again assume a position and importance which, if not in general economy superior to railways, yet may, in relative utility, compete in the transit of minerals and other merchandise, that this paper is now before you, and the immense capital embarked in canals certainly renders it a subject of national as well as pecuniary importance. A further enumeration of the progress of canal construction in this country is unnecessary, yet a glance at the commencement of inland works in America will be interesting; and in connection we find, as early as 1724, Cadwalladar Colden, then Surveyor-General of the colony of New York, suggesting a system of works somewhat similar to those now existing. Sir Henry Moore, the Governor of the colony, in 1768, also recommended the improvement of the inland navigation. These recommendations slumbered through the Revolutionary War which followed, to be again projected with the independence of the country. As in England, the improvement of the existing navigations was first in course, and, as early as 1791, Acts for surveys and estimates relating to the removal of obstructions to the navigation of the Hudson and Mohawk rivers were passed. In the following year, the Western and the Northern Inland Companies were incorporated, and, by 1802, the former Company had succeeded in spending an immense sum of money, with but very small proportional results. The

route now occupied by the Great Erie Canal was adopted in 1812, repealed in 1814, to be again revived two years later. Ground was broken near Rome in July of the same year, while the first boat passed from Lake Erie to the Hudson in October, 1825, thus consuming a little over 8 years in constructing the distance of 364 miles, with a total of 71 locks. The Champlain Canal was commenced in 1816, and completed in 1823, since which date the many lateral branches of the Erie have been added to the system, and the application of inland navigation extended to many of the other States. It is a fact of interest that the original dimensions of these canals were established by the Commissioners in 1817, at 40 ft. in width by 4 ft. deep, with locks 90 ft. by 15 ft.; but as early as 1834, the wants of a growing commerce demanded an increase of capacity, and in 1835 an Act of enlargement of the Erie Canal was passed, since which time the depth has been increased to 7 ft., its width to 70 ft., and the locks to 18 by 110 ft. Before the commencement of the Erie, the cost of transporting a ton of merchandise from Buffalo to Albany equalled £20, and consumed 20 days; the canal at once reduced the cost to £4, or $\frac{1}{5}$th, and the time to 8 days. But mark, that the mere enlargement of the canal again reduced the average cost of movement, including all tolls, to 10 shillings per ton, or $\frac{1}{8}$ of the expense previous to the improvements. It may be interesting to review some of the more or less ingenious attempts to overcome the disadvantages of towing by horses, and hastily glance at the various methods of propulsion by mechanical means, which have been especially designed to supersede animal labor in propelling boats on inland navigable waters, in Europe and America, up to the present time. In this enumeration we shall necessarily find among the first experiments some which have been broadly designed for purposes of general navigation, and touch upon the early history of the steam-engine, but, so far as possible, preference will be given to those where application to canal or river navigation has been the paramount idea of their inventors.

In 1472, long before canals, attempts had been made to substitute for the manual labor of oars the propulsion of boats by wheels moved by oxen; while, on the 17th of June, 1543, with a precision of date which throws much doubt on the probability, the Spaniards claim the construction of a steam-moved vessel. Mention of galleys driven by side-wheels are found in the years 1578 and 1587; while, in 1618, David Ramsay obtained a patent from the Crown to apply engines "to make boates for the carriage of burthens and passengers runne upon the water as swift in calms, and more saff in storms, than boates full sayled in great windes;" and again, in 1630, was issued to him a second patent for a similar purpose. The many schemes for propelling boats which have been carried to a farther or less degree of experiment or practical use since Ramsay's day, are too curious not to be classified, and at the risk of tediousness, the manner and means for obtaining power of various kinds are enumerated :—From wind, by sails, kites, balloons, and windmills on deck; from oars, worked by men, animals, and steam; from padd'e-wheels and screw-propellers placed in every possible part of the vessel, and variously constructed and driven; from the vessel's motion, and from the motion of mercury; from the current-operating machinery on board; from springs and from weights differently operated; from the explosion of gunpowder, and from gases, either generated or exploded; from the discharge of steam, compressed air, and from falling water. Electricity is to afford the motive power in 6 instances; while an endless chain lying upon the bottom of the canal, and passing over various parts of the machinery, has strong advocates. Some haul the craft along by a rope fixed on shore, and some again by a smooth or rack-rail on the banks, with which wheels driven from the boats engage. Thirteen sanguine inventors claim that a locomotive moving along the canal, and towing after the manner employed by horse-boats, is the only solution of the vexed question, while nearly as many believe that an atmospheric railway is the only system suitable. The larger number of workers in this field have affected the direct discharge of water at the stern as the greatest good, a less number by the discharge of air in various ways. One by discharging fire under water is peculiar, though hardly so curious as Congreve's device of sponges for propelling a vessel by capillary attraction,

forming a kind of perpetual motion. Several of the earlier motors were to achieve their end by thrusting poles against the bottom of the canal, two by water in a tube on the shore suitably connected with the boat. Bourne and others advise either wheels rolling on the bottom or the adoption of screws so working, which seem to have many disadvantages, but the action of reciprocating rods, armed with fixed floats or valved pistons, shaped as wedges, cones, or as hollow vessels, and worked at the sides or under the bottom of the boats, either in or out of channels, has always been a favorite plan, opposed again by a numerous class who allow the reciprocating motion, but insist that movable floats only can succeed. Variations of this last consist in hinged boards and collapsing propellers, operated in divers ways, while some, in their search for novelty, call all the others wrong, and place the floats at once upon an endless chain, by which they hope to use less power and gain more speed. Water or steam acting in flexible tubes end the list. Among all our counsellors whom shall we select? Some of these devices are deserving of more than such wholesale notice, and we will particularize a few of the more prominent. Passing over one hundred and fifty years, during which time we have the invention of the steam engine, and the early labors of such men as Papin, Savery, Jonathan Hulls, James Watt, and Symington, we reach the invention of Patrick Miller, who, in 1787, especially claimed an application of machinery for the purpose of inland navigation. His invention comprised either double or triple vessels, having two or three separate hulls, with one deck over all, with paddle-wheels, of any required number, placed in the space between the hulls, so as to be submerged to an advantageous depth. Originally designed to be operated by a capstan worked by a windmill or manual power, the arguments of Symington, who applied the steam-engine, changed the original idea of motive power, and successful experiments were made in the summer of 1788 and the winter of 1789, upon the Forth and Clyde Canal, where a speed of nearly seven miles an hour was obtained. Notwithstanding this success, it seems that Mr. Miller did not consider the invention as practical, since, in 1796, we find Miller again applying for a patent for the construction of vessels propelled by wheels worked by capstans, as in the original scheme. In 1788, John Fitch, an American, obtained a patent from the States of Pennsylvania, New York, New Jersey, and Delaware, for the application of steam to navigation, and also successfully opposed the application of James Rumsey for a similar patent the same year. Fitch succeeded in driving his steamboat eighty miles in one day, by means of six oars or paddles working perpendicularly on each side of the boat, similar to the strokes of the paddles of a canoe, but his invention came to no practical use. Rumsey, who had been refused a patent in his native country, came to England, and in November, 1788, obtained Letters Patent of Great Britain for propelling boats on rivers and canals, by alternately moving a valved box backward and forward under the keel of a vessel by means of his steam-engine. The box opened toward the stern, was provided with a valve at the forward end, which, opening as the box moved forward, allowed the water to pass freely, but, closing with the opposite movement, propelled the boat ahead. A second part of his specifications describes an arrangement for drawing water at the bow into a hollow longitudinal trunk parallel with the keel, and discharging the same at the stern by the reciprocating strokes of a large pump. Rumsey also devised two wheels projecting from the bow of a canal-boat, which carried an endless chain with floats. The current was supposed to actuate this mechanism, which, by operating a series of poles for pushing against the bottom of the channel, propelled the boat. The similitude of the plan with that of a man lifting himself over a fence by the straps of his boots is obvious. The death of Rumsey, in 1792, prevented any practical application of his inventions, though his associates, in the spring of 1793, obtained a speed of four miles per hour on the Thames, from a boat arranged upon his pump system as described, which boat Rumsey had nearly completed at the time of his death. Next in order, in the year 1801, Mr. Symington was employed by Lord Dundas to experiment, with the view of substituting steam for the horse boats on the Forth and Clyde Canal. After 2 years experi-

menting, and at an expense of over £7,000, the Charlotte Dundas was completed, and launched on the canal in March, 1803. In this boat were first combined all the principal features of our modern paddle-wheel steamers, viz., the double reciprocating engine, with connecting rod, and the crank on the axis of the rotary paddle-wheel. The paddle-wheel—for there was but one—was placed near the stern, in the centre of the boat. This seems to have proved a perfect success in regard to self-propulsion and towing of other boats; but though the efficacy of the system was proved, the opinion of the canal proprietors that the waves it created would damage the banks, prevented its adoption. Notwithstanding the decision of the Forth and Clyde managers, the Duke of Bridgwater, after a careful investigation of the advantages and the supposed drawbacks, gave Mr. Symington an order to build 8 boats similar to the Charlotte Dundas, to ply on his canal, but the death of the Duke, soon after, prevented the execution of the scheme, and poor Symington and his canal navigation were neglected together. The ingenious experiments of Stevens, Evans, and Fulton, in America, about this time, being applied for purposes other than canal propulsion, do not particularly concern this narrative, for although, in 1796, Fulton published in London a treatise on canal navigation, wherein he advocates raising and lowering of boats by means of inclined planes, yet he makes no mention of steamboats therein, though in January, 1803, he described some experiments with paddle-wheels as more advantageous than the system of chaplets or endless band of floats for propelling a system of boats, which were designed to be formed with bows and sterns convex and concave, so that several would form a line with almost continuous sides. Yet he does not seem, even after his practical success on the North River in 1807, to have again advocated steam for canal uses. In later years, this arrangement of boats has been revived again and again. Richard Trevethick and Robert Dickinson took out a patent in 1809 for moving an oar, provided with valves, forward and backward in a channel under a boat; and 2 years later one Rose received a patent for constructing a canal boat, with water-courses open to the water below and at each end, with 2 or more paddle-wheels and cranks acting on the water. No drawings are known to be in existence of these plans. In this same year were also granted 2 patents for propelling boats by discharging water at the stern by means of a steam pump, similar to Rumsey's principle, but no experiments are noted. In 1812, but 1 patent was issued for improvements in canal navigation, where endless bands traverse over wheels at the end or sides of a vessel, and carrying hinged floats to act on the water when propelling the boat, but caused to lie flat on the reverse stroke in a manner not plainly described. In the following year, we find an invention by Thomas Mead, who proposes a double endless chain moving around 2 wheels above and below 2 parallel tubes; on the chain belt are a series of pistons packed so as to pass steam-tight through the tubes. Steam from the boiler forces the pistons continuously along one tube, at the end of which they are successively detained and released by catches, and pushed forward a small distance by eccentrics. The steam escapes by a hole in one of the tubes, which is uncovered at proper times as the pistons require. In 1815, Richard Trevethick patented a screw propeller, consisting of a worm or screw, or a number of leaves placed obliquely round an axis, which revolves, preferably, within a cylinder at the head, sides, or stern of a vessel. In some cases the screw is to be made buoyant, and works in a universal joint, the advantage of which construction is hard to perceive. John Millington, during February of the year 1816, lays claim to a propeller more modern in its features than any preceding. He also claims forcing air into tubes, which operated against the water at the stern to propel the boat. In the same year, we have an arrangement with several cranks on the side of a vessel connected with each other by horizontal connecting-rods, upon which are placed vertical vanes of a curved shape, so as to act upon the water by the revolution of the cranks one way (but carried forward above the surface); and in the next a method of propulsion by operating oars, held vertically at each side of the boat, in a similar manner to Fitch's earlier experiments, except that, by means of cog-wheels, the oar blades were feathered to pass edgeways through the water during the return stroke. About

the same date, Niepce proposes propelling a boat by the pressure on the water of the gas and rarefied air produced by the inflammation of the essential oil of resin injected at intervals into an air-reservoir and there ignited. The gasses pass through tubes provided with valves into a well, from which they expel the water with force along a tube opening below water-mark at the stern of the boat. By the use of 2 receivers, and by spiral blowers refilling the air-reservoir, the propulsion is effected more evenly.

In 1818, John Scott patented an arrangement by which forked poles, operated by wheels, push against the bottom of the canal, and, in case the depth is unusual, broad vanes at the ends of the poles thrust against the water, and are lifted into the air for the return. We also find in this year hinged floats fixed to a reciprocating chain under the vessel. Two years later, George Lilley and James Fraser recommend the application of a forcing-pump to constantly supply water to a cistern upon the deck of a boat; while, by means of a condensing air-pump, the pressure of the air in the cistern is increased until the force of a stream of water, conducted from the bottom of such cistern to the stern of a boat, shall drive the vessel forward. Vanes driven by an engine, and oscillating through part of a revolution in an air-tight cylinder or drum floating upon the water, are also found to propel a boat, by alternately receiving water at one side of the vanes and discharging it from the other; and, in this same year, a sanguine inventor claims applying the paddle-wheels astern, or in the rear of the vessel, and so arranged that the part of the vessel which carries the machinery may be separated and applied to the stern of any number of vessels in succession to propel them. The next year, we have 4 inventions. The first places the propelling wheels in a horizontal position at one side of the deck, with the floats feathering as they return, folding against the periphery of the wheel by means of suitable levers, cog-wheels, and inclined planes, and thus prevent resistance to the water. The second revolves one or more pair of paddle-wheels in channels or sluices in the vessels, whilst the third, disdaining the aid of steam, operates his paddles entirely upon the treadmill system. The last is a repetition of the endless chain and floats. In 1822, the Brothers Binns claim the application of a rotary steam-engine with wheels feathering the floats by reason of loading the bottom edges of the paddles proportionate to their surface, which hardly seems certain in action at even a medium rate of speed, and a few months after, we have one of the earlier claims for increasing speed by the use of geared engines, though not specially claimed as applicable to inland navigation. In February, 1824, Moses Isaacs, whose name inclines us to the belief that he was of Jewish extraction, patents a swinging "fiery" furnace, which alternately heats 3 boilers, while the steam from the cylinders is received by the boilers first heated and now cooling. This scheme is decidedly visionary. An "ichthyodic oar" is next claimed by one Busk, which he describes as a "wedge between 2 planes under water moving back and forward, turning on an axis through its thick end, and so as to touch with its sides each plane alternately. Valves admit the water, and close when the wedge forces the water against them. The oblique pressure of the sides of the wedge on the water propels the vessel. In a modification of the above, a wedge is caused to move up and down in the water with its thick end forward and its edge horizontal, and includes in the specification revolving cones, with their axes horizontal and points turned towards the stern. He also presents as a novelty the pumping of water through tubes which, in his fondness for original names, he baptizes as a "Hydropetic propellent," and the very next month, in partnership with James Neville, he desires protection for drawing along a boat by opening and shutting planes fixed at the bows after the manner of the covers of a book, and also claims forcing air through tubes against the water. Two months later this same irrepressible William Busk appears as the inventor of a method of propulsion evidently taken from the action of the tail of a fish. An elastic plate, fixed at one end to an axis, is caused to vibrate back and forward in the water, or two such plates revolve from a projecting shaft at the stern; but Busk, with all his ingenuity of devices and nomenclature, does not appear to have realized either fame or fortune, and he subsides for a couple of years, when he brings up two

other arrangements quite as theoretical and impracticable as any that preceded them. The first record of invention in which a chain lying in the water of the canal, fast at one end, and passing round a wheel on board the vessel, which wheel being turned by machinery, the boat is propelled, leaving the chain behind on the bottom, is found in Samuel Brown's claim of March 15th, 1825, and is worthy of note, having been revived at various periods, and even reported at the present time as in use in Holland. The disadvantages of this system in regard to passing locks and bends of the canal, militate against it. As a modification of this principle, we were lately shown a plan whereby a heavy chain was tried on the Bridgwater Canal, but instead of using a direct pull as the propelling power, the chain was taken on board over the bow, and lowered, with considerable slack, vertically over the stern, the gravity of the hanging loop being expected to move the boat forward. It is unnecessary to add that this failed as a practical means of propulsion. In this year John and Samuel Seaward patent the employment of a wheel or wheels placed in an opening or well through the bottom of the boat, and revolving upon the canal bottom, or against the sides thereof, and by that means to propel or draw the vessel forward. These wheels were provided with projecting knobs on their peripheries, in order to take a firm hold of the ground, or, if desired, projecting arms or radii could be used, in which latter case the arms were arranged to slide in and out of hollow spokes, so as to freely compensate for inequalities of the bottom. We can imagine some difficulties and considerable mud involved in the practical solution of this problem. Next year we have paddle wheels at the bow or stern, which lift on deck for convenience in lockage, and also the employment of kites for drawing vessels; the multiplication of these kites was to give "indefinite power," and very indefinite it would be surely, not perhaps in the sense intended by the over-sanguine inventors. Congreve's device we have already mentioned. This patent, issued in 1827, comprises a broad, thick band of sponge around a cylinder free to revolve in the water. The water rises into this band on one side by capillary attraction, and an endless chain compressing the band by its weight on the other squeezes the water out. The difference in weight between the two sides causes the cylinder to rotate and to draw the vessel on, or to move paddles to propel it. Glass or metal plates may be used to create the capillary attraction, and mercury in a tank instead of water. No boats on this system are known to be in use. This year also brings out an invention for propelling boats by setting in motion the system of levers commonly known as "lazy tongs," and probably intended to have hinged floats at its extremities; and three months later an idea is made public where hinged vanes, obtaining their reciprocating motion from rocking shafts, are employed. In 1829, two spirals at the stern of a boat, and covered by removable plate iron cylinders, to protect the banks from injury, is claimed by Julius Pumphrey; in 1831, a scroll-shaped propeller, revolving in a scroll-shaped case, by William Hall; while, in 1832, Woodcroft patented his increasing pitch screw-propeller, applied at the side or at the stem of a vessel or boat; but what Fulton did for the paddle-wheel in America, and Bell in this country, namely, its practical introduction, we must award to Ericsson in respect to the screw-propeller. Captain John Ericsson, as the first actual demonstrator of the submerged screw-propeller, in 1837, has afforded us a means for propelling boats on narrow water-ways, without the disadvantages arising from the use of paddle-wheels operating upon the water surface; for although, besides those lately mentioned, Bramah, in 1785, patented a propeller on the principle of the sails of a windmill or the blades of a "smoke-jack," Littleton, in 1794, Fulton in 1798, and Edward Shorter, in his claim for "a perpetual sculling machine," in 1800, yet to Capt. Ericsson is due the credit of the first successful improvement, carried out in May, 1837, on the John O. Sergeant, with a double propeller, though his patent is dated nearly a year previous. The success of this steamer induced the construction of the Robert F. Stockton, which, though provided with a double propeller similar to the Sergeant, was as frequently worked with one only. After several trials of her powers in England, she crossed the Atlantic in 1839, where she was at once sold to the Delaware and Raritan Canal Company for towing their

boats. The value and importance of the screw to navigation having been clearly demonstrated of practical value, a number of screw boats were put on the lines of inland navigation which connected Lake Ontario and the St. Lawrence *via* the Welland Canal, and also on the route of the Chesapeake and Delaware Canal, which united the Chesapeake Bay and the southern waters with the river Delaware and the north. As instancing the capability of canals even in competition with railways, we find, according to Woodcroft, that the introduction of the small screw steamer, the Ericsson, between Philadelphia and Baltimore, by the inland route of the Chesapeake and Delaware Canal, completely ruined the goods traffic of the Philadelphia and Baltimore Railway. In the competition with this single vessel, the railway was compelled to reduce its passenger fares one half, and even with the attempted aid of the State, it lost its entire freight business. Capt. Ericsson also built, in 1839, an iron screw propeller, named the Enterprise, to run as passenger boat on the Ashby-de-la-Zouch Canal, but the introduction of railways prevented her being profitable for this purpose, and she was afterwards used to tow coal barges on the Mersey and Trent navigations with entire success. Returning to our inventors, we find Sir John Scott Lillie patenting, in 1836, the application of atmospheric railways for towing canal boats, but the practical inconveniences which have hitherto prevented the use of locomotives along the canal banks for the same purpose would hold ground as strongly here. Intending to overcome all objections, an enthusiastic American started a joint stock company, about 2 years since, for the purpose of constructing an elevated double railway over the line of the Erie Canal and its branches, from which the boats underneath could be towed at any speed; but the estimates of costs certainly exceeding $4,500,000, while the dividends were not so positive, there yet remains opportunity for English subscribers to invest. However, this only goes to prove the awakening to the necessity of applying to canals some of the attention and improvements so liberally bestowed on all other carriage systems, and, sooner or later, a fortune will reward the lucky inventor who shall solve the great problem of canal propulsion.

In case of the ordinary shaped boat being dragged along the canal by steam towage, any increase of speed, commensurate with the expense incurred, will create a wave more destructive to the banks than the use of an ordinary propeller, so that any system of railway towing requires the adaptation of a complete fleet of boats specially devised for high speeds with small resistance. For the tables on the resistance of canal boats at different speeds, and the disturbance of the water surface, reference is advised to the experiments of Stevenson, in 1818, Beran in 1832, of Palmer, as published in the first volume of the "Transactions of the Civil Engineers," with Professor Barlow's report thereon, and those conducted by McNeil on behalf of the proprietors of the Forth and Clyde Canal.

This paper would be incomplete without mention of the experiments of Fairbairn, in 1830 and 1831, as instanced in his "Remarks on Canal Navigation, illustrating the advantages of steam as a moving power on canals." The preliminary experiments of light single and double gig boats on the Forth and Clyde Canal, moved at a high rate of speed and variously loaded, as well as the partial success of the steamer "Cyclops," built under the direction of Mr. Grahame, of Glasgow, with a single stern paddle-wheel, induced Mr. Fairbairn to suggest the construction of a small steamer named the "Lord Dundas," 68 ft. in length by 11 ft. 6 in. in breadth, and 4 ft. 6 in. in depth, provided with a wheel through 3 ft. 10 in. wide, and a paddle 9 ft. in diameter, driven by a 10 horse-power steam engine; but he also recommends as an after improvement, a steamer with two narrow paddles, close to the stern and on each side of the rudder, urging that this plan would remove every impediment to the free access of water to the paddles, and allow an open outlet for the discharge, the paddles to be protected by fenders, sliding down on the outside of the wheels. Mr. Fairbairn figures the cost of conveyance of a passenger by steamer between Edinburgh and Glasgow, 56 miles, at 2d., or less than $\frac{1}{12}$ of the least possible expense by horses. Though the results given by these boats were not in practice so satisfactory as expected, yet Mr. Fairbairn never despaired of a future when steam should be as universal in

inland navigation as it at present is in all other of the arts.

Following up the interest which about this period seems to have been excited on canal behalf, we have an influx of applications of machinery to inland water propulsion, many of which are but modified forms of the less elaborate devices we have already mentioned, in which the paramount idea of their authors would seem to be that of advancing the boat without creating a wash damaging to the canal banks, and with arrangements for discharging the water directly aft or directly down, while some have curved platforms, or "*wave quellers*," to moderate the swell produced by the propelling machinery.

For actuating vessels on canals, one Henry Pinkus submits a railway constructed alongside, with one rail, on which a suitable carriage traverses. A tube conveys gas along the rail from a stationary engine and reservoir. The gas is brought through a longitudinal valve on the rail tube to a flexible tube from the carriage to a reservoir on board the vessel, and from the pressure here derived machinery is set in motion, which again, by an endless band, turns two horizontal wheels (one on each side of the rail) on shore, and supported on the carriage before mentioned. Finally, these wheels, by revolving, draw the carriage forward, and the carriage, in its turn, tows the vessel. We can imagine that this plan would never depend upon its simplicity for success. The same inventor offers the plan of a steam-engine on a vessel driving a horizontal wheel, which, by an endless band, turns on shore a pair of horizontal wheels similar to those described, and these, by revolving, tow along the vessel. The carriage holding these wheels has a curved guard arched over it, formed like the rail on which the carriage runs. This is to enable another carriage meeting it to pass over the first, thus providing for the use of the same rail by boats travelling in opposite directions. In place of the steam-engine, the machinery on board may be turned by an electro-magnetic engine, actuated by electric currents from shore. Whether this "leap-frog" arrangement for passing-boats could be extended to skipping playfully over the locks, is not stated.

A claim, in 1841, proposes a locomotive steam engine on the towing path to drag itself along a chain fixed at one end, and the boat by a towing line to the engine; while another alternately expands and contracts an elastic sack in a water channel along the bottom of the vessel by the smoke from a furnace, and thus ejects sufficient water to propel the boat. Later on, there are variations of this. Still another drives an upright shaft in a vessel which carries a horizontal grooved wheel, on which is an endless rope, moving a drum on a carriage on shore, by which its wheels are turned, so as to advance the carriage, which then tows the craft along. The carriage is guided by a wheel in front, directed by a man. Steam is made to issue from a pipe against the air in one, and cog-wheels working into a rack-rail on the banks in another, while a third places an exhausted atmospheric tube at the bottom of the canal, and moves the boat above by a travelling piston. A fourth inventor makes his tubes of wood, and places them upon the banks or on piles driven along the canal. In fact, "about this time," as the almanacs say, the numbers that considered themselves each the sole possessor of the idea of working canals by atmospheric pressure is amusing. In 1847, we have flexible tubes placed under water on each side of a boat. They are alternately filled with steam and allowed to collapse. The boat is supposed to advance by the action on the water of the protuberant parts of each tube. There is certainly no needless complication of details about this. In this year we find proposed the towing of canal boats by compressed air contained in portable reservoirs, and an arrangement added to heat the air, in order to restore the caloric lost by its expansion. The next year, a patent is granted for a tube laid along a canal, and water forced through it under pressure, enters nozzle pipes, fixed at certain intervals along the tube. Connected to the boat to be propelled is a receiver, with a series of open cells, and as these pass under the end of a nozzle-pipe a valve is opened which allows the water to impinge on the cells successively, and thus force on the boat and the receiver, until they set the next nozzle-pipe in action, and close the valve of that which is passed. Still, notwithstanding the ingenuity of this scheme, one would desire much soli-

citation to invest in its success. Next, we have a shaft extending the entire length of the vessel, with propellers on its projections working one at the bow and one at the stern. The advantages of this novel feature are not mentioned. The last of 1851, a patent for fastening iron rails upon walings, supported on piles, and extending the entire length of the canal on both sides was issued. Wheels on each side of the boat, and driven by a steam engine, are rotated on these rails and pull the boat. Instead of locks, the boats move up inclined planes, gear wheels engaging in racks on the walings, while rollers at the bottom support part of the weight. Unless compensated for all variations of water level we might, expect to find occasional lines "high and dry." In 1856, a provisional is filed for propelling boats by discharging a stream of fire from an inflammable composition in a tube into the water at the stern, but from want of faith or of means, the scheme was abandoned. At a later date, John Bourne patents an arrangement of propellers at the bow, or paddle-wheels at the side to work on the bottom in shallow water, "and thus clear it away" and propel the vessel.

With their usual ingenuity and perseverance, American inventors have explored this branch of engineering practice, but, like their Translantic brethren, have taken the question of mere propulsion as the desired end, attaching thereto some device to still the agitation of the water, and very similar schemes in this field to those already touched upon have been the result of their labors. The question is not that of a motive power alone, but simple application of the motor that will prevent waves at the bow, suction and settling at the stern, and afford a mean speed of from three to four miles per hour when fully loaded, with a minimum quantity of fuel. The propelling machinery must be simple and compact, that it may be managed by men not especially educated for the purpose, to economize both space and expense. These are the requisites, and a boat fulfilling the conditions will be sure of success.

Some 25 years ago, Captain Ericsson launched a boat with a screw propeller at each side of the bow for the Champlain Canal. There was no difficulty in the propelling force, but it did not carry sufficient cargo to be profitable. Henry R. Worthington, 5 years later, ran a steam canal-boat from New York to Oswego during one season. This vessel had a skew paddle-wheel on each side of the bow, and a *fighting crew* to overcome any *prejudices* which the opposition boatmen should venture to express. Notwithstanding the *extreme force of the arguments* employed, the enterprise was abandoned with the season, there not being sufficient capacity for a paying freight. A boat was fitted with feathering side-paddles, some 16 years ago, by John Baird, for the purpose of towing barges on the Erie Canal, but not carrying cargo itself, and depending on the tonnage fees from the old boats, failed to be a pecuniary success. In 1860, there was a line of sharp propellers built in Buffalo, New York, which, with an expenditure of from 3 to 4 tons of coal per day, averaged 6 and 7 miles per hour. The annoyances caused by the opposition of the horse-boats, and the heavy expenses of fuel and engineers, caused their removal to a lake route. Wire rope traction and submerged chains have been frequently tried as well, and found wanting, the canal locks and numerous bends having so far proved insurmountable obstacles.

As late as last year, the duck-foot, or expanding propeller, so many times tried in England, was attempted in Albany, New York, by Mr. Cornelius T. Smith, and also at Cumberland, Ind., by Mr. Marshall, without satisfactory results; while a Cincinnati doctor, abandoning his pills, conceived that he had hit upon the correct thing by the similar device of a reciprocating hinged shutter. The result made more noise and waves for the canal than greenbacks for his pocket, and our worthy disciple of Esculapius returned to his surgery. At Lockport, New York, a wheel with spokes on the surface, made so as to rise and fall in a recess in the boat, and rolling along the bottom of the canal, was lately tried. It was driven by a chain, and so propelled the vessel. No provision for deep water or soft mud being made, this enterprise came to grief. A scheme now being tried consists of a canal tug-boat provided with an endless band or chain on each side of the boat, carrying paddles, which, dipping in the water to propel the vessel, return through the air in a manner akin to similar plans

which have been tried here and abandoned. There has been a large sum of money expended, and a frightful noise is produced, still otherwise it is not considered a success.

We close the list by calling attention to the arrangement for applying steam-power to canal-boats, which has been recently designed and practically operated in the United States by Mr. Thomas Main, mechanical engineer, of New York, and presented in longitudinal section and plan on the diagram. It will be seen that it possesses all the happy features for obtaining propulsion by steam on narrow channels, for which many have striven, but none before fully accomplished; but, as has been justly remarked by a modern writer, "an invention is progressive in a regular series." There may be a long order of elementary principles developed without the occurrence of a single practical result, so far as any useful application is concerned, but the perfect machine will be found by somebody. Analyze the diagrams, and there will be found a propeller placed in the bow of the boat (its advantages are readily seen), woking in a channel underneath the vessel. The peculiar sloping of the channel is the most convenient arrangement for overcoming any tendency to create a wash, which has been, in some form or under some name, the object of several inventions. The high pressure machinery and tubular boiler is the very locomotive engine so strongly urged by Mr. Fairbairn, only in this instance the inverted cylinder and upright boiler economize the space to the utmost. In fact, the general position of both the channel and the motor interferes least with the cargo-bulk, and the water, after passing the propeller, is deflected in the line of least resistance, and passes under the entire length of the boat to form scarcely a ripple upon the surface, while the channel sides are a safeguard against any lateral waves. It may be asked if the peculiar shape of this channel does not cause friction of the water, and great loss of power. This would certainly be inconvenient in any case of high speed, but in the slower movement of canal traffic, we shall not find any appreciable loss from this cause. A boat constructed on this principle has been for some time regularly employed upon the Erie Canal in America, carrying, besides the machinery, 200 tons of cargo at a rate of 3 miles per hour, including lockages, or 72 miles in 24 hours, consuming only a ton of coal at $5, against $28.50 for 2 days' horse towage, for the same distance—a saving of half the wages of crew, and transporting the goods in the same proportion of time—and additional to its own cargo, can tow a similar loaded barge at very nearly the same speed. This boat can go through a lock in 6 min., against 12 min. required for a horse-boat, and is then handled by one man with ease. There is no injurious action on the banks, and the boat can leave the canal, and proceed as quickly and safely on river navigation with her self-contained power. In 12 months, such a boat, 70 ft. long by 16 ft. wide, and 9 ft. depth of hold, with an 8-in. cylinder, driving a 4½ ft. propeller, can pay for her entire cost from the saving over horse-boats, to say nothing of the certainty and despatch which alone insures the confidence of the mercantile community, and is the foundation of extensive patronage. Every comparison between the expense of steam *versus* horse-carriage, that is attainable, gives great economy to the former system; and sooner or later, with her canals enlarged, and steam-propelled boats giving a system of trackage infinitely superior, cheaper, and more regular than anything hitherto dreamed of, England's internal navigation will take a position worthy of those talents that conceived them. The party of croakers who are ever found in opposition to improved communication, will, with the present *employés* and certain railway interests, loudly cry out against any innovation trenching on this special province, and predict sad disaster to the country by any interference with the ancient customs now cherished so fondly; but if the step is not now taken in the spirit of enterprise, it will be forced upon the country as a necessity, after other nations shall have led the way. Notwithstanding the immense amount of freight conveyed by railways, now burdened nearly to their utmost limits, we find trade, with its gigantic strides, tasking the carrying capacity of the canals in spite of their many disadvantages, and ever steadily increasing in its demands. In 1835, before the opening of the London and Birmingham Railway, the through tonnage conveyed on the Grand Junction

canal was 310,475 tons, and in 1845, after ten years opposition of this road, the tonnage had increased to 480,626 tons; while, at the annual meeting of the canal proprietors in 1860, the receipts for the previous six months had been the largest ever experienced.

America, at the present moment, is alive to the necessity of canal improvement. Nearly £4,000,000 have recently been recommended by the Canadian Canal Commissioners for the enlargement and construction of slack water navigations. And, within a few weeks, the Legislature of New York have introduced a bill, offering a reward of $100,000 for the best plan of canal navigation, in the substitution of steam or other motive power for animal labor; and England should not remain backward in the race, especially since to her canal system she owes so much of her present prosperity and greatness.

The cumbersome barge, with snail-like advance, feebly contrasts with the iron horse, thundering by with its speed and power. Yet, improved as they should and must be, canals will always continue to form an essential part of internal communications, to be missed quite as much as roads, railways, or even the telegraph itself.

In conclusion, the author expresses his sincere regret that this glance at the canal system, and the mechanical methods which have been suggested as applicable to the propulsion of their boats, had not fallen into abler hands. Its compilation has been gathered from many sources and authorities, with but limited time spared from usual avocations. But trusting that it may at least draw attention to a most important field in the economy of nations, such as it is, this paper is presented in the hope of a favorable reception.

ON THE PRODUCTION OF ALLOYS OF IRON AND MANGANESE, AND ON THEIR APPLICATION TO THE MANUFACTURE OF STEEL.

From "The Journal of the Iron and Steel Institute."

The properties of pure alloys of iron and manganese have not, as yet, been completely investigated. It is assumed by many metallurgists that the presence of a sensible proportion of manganese in malleable iron or steel, improves the ductility and elasticity of the metal, and that for this reason the addition of manganese is indispensable for the production of good cast steel. Other metallurgists, on the contrary, maintain that manganese has a tendency to produce hardness and great cohesive strength, at a sacrifice of those properties of malleability and ductility which are principally looked for in all modern kinds of "soft steel." According to this latter view, the function of manganese in steel making is simply to remove all surplus oxygen and silicon from the mass, and (in combining with these noxious elements) to disappear from the metal and pass into the slag.

This difference of opinions with regard to the theoretical position of manganese in the process of steel manufacture, does not preclude an absolute unanimity amongst steel makers in this country and abroad, as to the practical necessity of employing manganese in the manufacture of cast steel. In the old process of melting blister steel in a crucible, the addition of carburet of manganese—as patented by Josiah Marshall Heath in 1839—or the addition of an oxide of manganese mixed with a sufficient quantity of carbon for the final reduction of the manganese, are practised at the present day. The only modification which has been effected in recent years with regard to this process, is the substitution of spiegeleisen, a substance which may be considered as an alloy of carburet of iron and carburet of manganese, instead of the pure carburet of manganese originally employed by Heath. In the Bessemer process, the addition of an alloy of iron, carbon, and manganese, is an essential element of practical success, and a similar employment of manganese alloys has been adopted in the Siemens-Martin process, and in several other modern methods of steel manufacture.

The reduction of pure manganese from its ores, or the production of a pure carburet of manganese, presents considerable practical difficulties. The great affinity of manganese for oxygen, and the readi-

ness with which the oxides of manganese combine with silica to form a slag which is liquid at a comparatively very low temperature, render every process for reducing metallic manganese extremely difficult to conduct on a large scale, and very expensive in practice. The production of metallic manganese has, therefore, never been successfully carried out in commercial practice; and it appears that Heath himself abandoned his original idea of manufacturing carburet of manganese, and preferred to charge the steel-melting crucibles with oxide of manganese and carbon, on account of the saving of expenditure attained by this change.

The principal supply of metallic manganese for modern steel manufacture is obtained in the form of alloys of iron and manganese produced by a variety of processes, and differing in their nature and qualities to a considerable extent.

Alloys of iron and manganese are reduced from natural or artificial mixtures of the ores of both metals with all the greater facility the higher the proportion of iron, and the smaller the percentage of manganese is required for the product. The ordinary pig iron produced in the blast furnaces of Sweden, Austria, and many other localities, contains from one to three per cent. of manganese. This is due to a small percentage of carbonate of manganese in the spathic iron ores of these localities, and it is a mere question of the quantity of silica present in the slag which determines the exact percentage of manganese which is reduced and brought down with the metal.

A specialty of such pig iron which contains a proportion of from 7 to 11 per cent. of manganese is the well-known spiegeleisen from the district of Liegen, in Rhenish Prussia. This pig iron is made from a spathic iron ore, which is a crystallized compound of carbonate of iron and carbonate of manganese, and which occurs in a large vein in a mountain called the "steel mountain," at Müsen. The production of spiegeleisen, however, requires a particular management of the furnace; it is necessary to protract as much as possible that part of the smelting process which is destined to the carburization of the reduced metals, and for this reason the charges must be so managed that the ores are quickly reduced, but that a long time is afforded to the reduced spongy metal before actual fusion takes place. The iron must be carburized at a temperature which is not sufficiently high for the reduction of silicon from the slag, yet at the same time the temperature at which manganese is reduced from its ore is nearly as high as that which will allow the silicon to pass into the metal. The presence of a considerable percentage of silicon, however, would prevent the production of specular iron, since the presence of silicon in molten iron has the tendency to drive the carbon out of its state of combination, and change it into graphite. The iron, instead of being specular, would become gray or mottled according to the temperature of the furnace, and its properties would be different from those of the spiegeleisen proper. On the other hand, if the temperature of the furnace is too low, or the time required for the carburization is too short, common white iron will be produced containing only a small proportion of combined carbon, and very little manganese.

The principal art in making spiegeleisen consisted formerly in making the ore capable of quick reduction by calcination, using burnt lime and only a small quantity of clay slate as flux, in order to reach the stage of carburization as quickly as possible, and applying cold blast and charcoal in order to keep down the temperature of the zone of fusion, and thereby protract the preceding stage to the utmost extent possible. With recent improvements and the necessity for economy, the ironmasters of Liegen have learnt to make spiegeleisen with hot blast and coke, with utilization of waste gases, and a high temperature in the zone of fusion. This is done principally by keeping out the silicon with an overdose of burnt lime, which also assists in preventing the sulphur from the coke from acting injuriously upon the iron.

With all these precautions, however, it is not possible to produce speigeleisen at all times and continuously in the same furnace. Fluctuations in the temperature and pressure of blast, and similar apparently very slight causes, will suddenly change the produce from spiegeleisen into gray or mottled iron, if the heat is excessive, or the slag too rich in silica, or the coke too much contaminated with sulphur; or common white iron will be produced if the temperature gets too low, or the bur-

den too heavy. With the best managed blast furnaces, intended specially for making spiegeleisen, only 70 to 80 per cent. of the total annual produce is iron of that class, the remainder being either gray or white, according to the side to which there is a greater liability of error in the particular furnace.

The proportion of manganese in the spiegeleisen from the Liegen districts rarely exceeds 10 per cent., and the average percentage of manganese in this material is about 7 per cent. The quantity of combined carbon in the spiegeleisen is almost constant, and amounts to 5 per cent. In adding a dose of spiegeleisen to a charge of decarburized iron it is, therefore, unavoidable that a proportionate quantity of carbon must be added for any given quantity of manganese which it is desired to introduce into the charge; and this leads to a difficulty in making very soft kinds of steel, which has always been very seriously felt by all Bessemer steel makers, and has been overcome only to a certain extent by great experience in the management of the converter. The actual necessity for making very soft steel with Liegen spiegeleisen is to "overblow" the charge to such an extent that there is oxygen enough left in the metal to combine, not only with all the manganese and silicon, but also with the greater part of the carbon introduced by the spiegeleisen. This practice has made it possible to apply ordinary spiegel to the manufacture of the softest kind of Bessemer steel; but it is an acknowledged make-shift, which has numerous well-known disadvantages, and the demand for richer alloys of iron and manganese has, for a long time past, been felt and acknowledged by every steel maker in this country.

Mr. Henry Bessemer was the first to point out this demand publicly in his specification for the manufacture and application of a so-called triple compound of iron, manganese, and silicon, instead of the ordinary spiegeleisen, to the manufacture of Bessemer steel. The mode of manufacture of this triple compound, as indicated by Mr. Bessemer, has been practically carried out by Mr. Prieger, of Bonn, and alloys of iron and manganese reaching occasionally as high a proportion as 60 per cent. of manganese have been produced by this process. The mode of operation is understood to be as follows: A graphite crucible is charged with a mixture of granulated cast iron, peroxide of manganese, and powdered bottle glass, and to this a large proportion of powdered charcoal is added. The reduction of the metal takes place at a very high temperature, and the alloy is richer in manganese in proportion to the heat. This process has been taken up by several steel makers, but has been finally abandoned on account of the excessive expenditure which this mode of manufacture involves.

Another process for the manufacture of ferro-manganese has been invented and patented by Mr. Wm. Henderson, of Glasgow. The claims of Mr. Henderson's patents are embodied in several specifications filed between the years 1860 and 1869. The manufacture of ferro-manganese seems to have been intended by the inventor to form only an accessory part of his method of metal extraction, which is described in his numerous patents. This process has been at work for a considerable time at the Phœnix Foundry, in Glasgow, by Messrs. Thomas Edington & Sons. It consists in reducing upon the open hearth of a Siemens furnace a mixture of carbonate of manganese and oxide of iron, in the presence of an excess of carbon, and by means of a neutral or reductive flame. The furnace bottom is carefully prepared from ground coke, consolidated and baked up to form a solid and durable carbon crucible on a large scale. The charge of oxides is ground up to a fine powder, and intimately mixed with powdered charcoal or coke, and the whole mass when charged and heated to a red heat for several hours becomes converted into a metallic sponge containing the reduced metal from both oxides, which is capable of being run down into a regulus by elevating the temperature to a full white heat. The quantity of manganese reduced in this manner is principally dependent upon the high degree of temperature given to the metallic bath at that stage of the operation. For this reason, and also on account of the necessity to avoid an oxidizing flame, the Siemens furnace is indispensable for this mode of manufacturing ferro-manganese. With all precautions, however, it is not possible to reduce all the manganese from the charge, and bring it down into the regulus. This is caused principally by the silica which is present in the mix-

ture of ores or in contact with them during the operation. The affinity of the oxide of manganese for silica is so great that the reduction is almost entirely stopped so long as there is any free silica in contact with the manganese ore. The product of the combination is a liquid slag of a characteristic pale green color, and which contains a very high per centage of manganese. The metal entering into this combination is, therefore, altogether lost for the metallic regulus, and only a part of it can be recovered by a subsequent utilization of these slags in other processes.

With proper selection of materials the average proportion of the alloy obtained by this process is from 20 to 30 per cent. of manganese. A furnace of ordinary dimensions, and worked by one man, will produce about 15 cwt. of ferro-manganese every 24 hours. The principal element of expenditure is the cost of the carbonate of manganese, which is subject to considerable fluctuations. At the maximum quotation which this substance now commands in the market, the cost of manufacturing 1 ton of the ferro-manganese of 20 to 25 per cent. is about £7, independent of royalties; but with improved experience, and by the further development of this process, the expenditure may in all probability be reduced very considerably in future. The value of a rich alloy of manganese to the steel manufacturer is very great. For the manufacture of the softest kinds of steel, an alloy containing 15 or 20 per cent. manganese has, at one time, been considered an indispensable addition by many of our leading metallurgists. For this reason, the price which steel makers used to pay for this alloy was very high. The rule laid down originally by Mr. Bessemer himself was to rate the ferro-manganese at £1 per ton for every unit of manganese it contained. By this rate the value of the 25 per cent. metal would reach £25 per ton. Commercial experience has, in the course of events, decided against this somewhat arbitrary mode of calculation; and the standard which is now put upon the value of ferro-manganese is taken from the actual price of Prussian spiegeleisen, and compared with the price of a mixture of ordinary hematite pig, with that quantity of ferro-manganese which will bring the mass up to the same percentage of manganese as that held by the spiegel. Taking, for instance, the price of spiegeleisen which averages 7 per cent. manganese, at £7, the equivalent mixture of hematite iron and ferro-manganese of 21 per cent. will be made up as follows:—

Two tons hematite iron, taken at £4.....	£8
One ton ferro-manganese, at.	13
Gives three tons of metal, of seven per cent..	£21

It appears, therefore, that the commercial value of a 21 per cent. ferro-manganese, under ordinary circumstances in this country, must be taken at £13 per ton as a minimum. It appears equally obvious that the manufacture of these artificial alloys will be a suitable and remunerative industry, and will form a useful accessory to every Bessemer steel works in this country. The steel makers will obtain a better and more regular supply of spiegel, and will make their works independent from all accidental fluctuations and inconveniences of the spiegeleisen trade, such as now exist between this country and the Liegen district.

The St. Louis "Journal of Commerce" states that during the coming season the Vulcan Iron Works Company of South St. Louis contemplate erecting a blast furnace that will surpass in size anything of the kind in the United States. The new furnace will stand on 12 columns, each 13 ft. in height; will be 25 ft. interior diameter, or bosh, and 100 ft. high. It will have 5 times the cubical area of any furnace now in Carondelet. The blast will be propelled by 2 powerful engines. Her hot blast will be entirely of fire-brick, encased in wrought iron, and it is expected that a heat of from 1,400 deg. to 1,600 deg. will be obtained. The company already have 2 furnaces, one of which has been in blast since the 14th of November last, during which period it has yielded between 5,000 and 6,000 tons of pig iron, and is now turning out from 48 to 50 tons per day. Furnace No. 2 will be put in blast immediately.

The largest rope in the world has been completed in Birmingham, England, and is about 6 miles long, 5¼ in. in circumference, and weighs over 60 tons.

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THE BIG GUN OF WOOLWICH.

From "Nature."

Whether considered as a weapon of terrible power or simply as a specimen of skilful and successful forging, the 35-ton Fraser cannon is without parallel. Of extraordinary strength and proportions, and withal so carefully, and, one might almost say, elegantly finished, this magnificent gun is indeed a masterpiece well worthy of the greatest factory in England, from which it emanates. Cannon of larger dimensions have, it is true, been produced capable actually of delivering a heavier projectile than that employed with the Woolwich weapon, but none of them are to be in any way compared with this, either in respect to battering power or length of range. That the gun is, moreover, not merely a show production, as was the case with the monster Krupp cannon, but a really serviceable and efficient fire-arm, is shown by its endurance of the severe test to which it was subjected at proof. On this occasion the 700-lb. projectile was thrown from the gun by the enormous charge of 130 lbs. of gunpowder—the largest, in fact, that has ever been safely consumed in any fire-arm—the explosion being without the slightest injurious effect upon the steel bore or surrounding wrought-iron castings. The solid cylinder of iron which constituted the shot, issued forth at the terrible velocity of 1,370 ft. per second, and, after travelling some 50 yards, buried itself in the butt of loose earth to a depth of 33 ft.

The pressure of the gas at the time of explosion was, as may be supposed, exceedingly great, and herein obviously lies the great difficulty to be overcome in the construction of large guns; this pressure or strain, we find, increases in a much greater ratio than the amount of powder that is burnt would appear at first sight to justify, and for this reason large guns require to be proportionately much stronger than little ones. Thus, in the present instance, when a charge of but 75 lbs. of powder was fired, the pressure of the gas upon the copper piston at the rear of the projectile was shown to be 17 tons per sq. in., while 130 lbs. of powder (not double the former charge therefore) gave a pressure amounting to 64 tons on the sq. in. It has, by the way, been questioned whether this method of estimating the pressure by means, namely, of a copper piston which is pushed in upon itself, affords a strictly reliable test, but in any case there can be no doubt that the strain upon the gun is increased in a greatly increasing ratio to the quantity of powder consumed. When we state, therefore, that the weapon withstood in every part this excessive strain, and that, under ordinary circumstances, the cartridge will contain but 90 lbs. of powder, there is every reason to believe in the solidity and perfection of the structure.

The data obtained by the firing of the gun at proof, lead us to hope for very successful results from its employment. It is calculated that at a distance of 50 yards the heavy projectile would be thundered forth with such force as to penetrate 14½ in. of solid iron, an armor plate such as no vessels of our present construction are enabled to carry. At 2,000 yards—at upwards of a mile, therefore—the shot would possess enough penetrating force to pass clean through the side of the strongest iron-clad afloat—those of the Hercules class—or, in other words, is endowed with impact sufficient to pierce 12 in. of iron; and it must be remembered that this last-named distance is one at which gunners can make very good practice, so that, under ordinary circumstances, every other shot would take effect against a target such as is presented by the keel of a large frigate. As regards extreme length of range, a quality of some importance, when, as in the recent instance of the Paris siege, great projecting power is of more importance than precision of aim, this Fraser gun may vie with almost any other, with the exception, perhaps, of Whitworth's cannon. The utmost distance to which the "Woolwich infant," as it has been nicknamed, will in all probability be capable of projecting a shell is about 10,000 yards, supposing the arm to be laid at an elevation of some 33 deg.

So satisfactory, indeed, has this experimental structure turned out, that a further batch of sister guns have forthwith been commenced, and will serve to arm some of our heavy iron-clads which are now building. Only a small number of

such weapons will be carried by these vessels—2, or at the most, 4 apiece—and thus our modern men-of-war will present a perfect contrast to those of a dozen years ago, when a ship, being regarded merely as a box of guns, sometimes received on board as many as 130 cannon. Nevertheless, a broadside delivered from 4 guns of these giant dimensions (for the whole armament being carried in turrets, may be brought to bear at one time), representing almost a ton and a half of metal, very far exceeds that which an old first-class three-decker could throw into her antagonist, and would indeed be sufficient to sink most vessels at a first discharge.

As regards the method of building up these large guns, we need say nothing, seeing that the subject was fully discussed recently in these columns. It may be of interest to know, however, that in the present instance, as much as 50 tons of metal were employed in constructing the arm, and that at one time 30 tons of this was brought to a glowing white heat for the purpose of welding. The reverberatory furnace in which this massive coil was heated is an apartment in which a dozen persons could dine comfortably, and the length of the bars before coiling amounted to upwards of 1,200 ft. The length of the arm is 16¼ ft., and its extreme diameter 56 in.

IRON AND STEEL NOTES.

The Iron Trade in England.—There is no change of any importance to report in prices from the North of England, but the daily change in increased efforts to stimulate production is very apparent. This is an evidence of present prosperity, and an indication of the view which those engaged in the trade take of the future. Fresh iron mines are being opened up, fresh furnaces are in course of erection, fresh companies are in process of formation, the one object of all being to develop the resources of the district to the utmost possible extent. In the meantime shipments to the Baltic and various Continental ports are going on with increased rapidity, and masters are busy with the completion of orders already in hand. Fresh contracts are not made with such rapidity as, in consideration of the facilities of production, might be desired; but it is generally thought that the present lull will be succeeded by an influx of orders, which from one cause or another have been held back hitherto. Prices are—for No. 1, 51s.; No. 3, 47s. to 47s. 6d.; No. 4, 46s. to 46s. 6d., net. American orders continue in a great degree to support the market. In the North, the United States, and the New York district especially, are large buyers, and in the South the Brazilians have supplied extensive orders. Canada, too, is in the market not only for rails, but for iron for bridge buildings. The exports from Wales during April were—Cardiff, 23,214 tons; Newport, 9,736 tons; Swansea, 2,856 tons=35,806 tons. The market is very firm, and as the general impression gains ground that higher rather than lower prices will rule, buyers are more desirous to pass contracts at current quotations. At the same time large orders do not come in with that rapidity which has been looked for. The make of pigs is stimulated in this district as in the North, and shipments are large. Swedish iron has met with purchasers of Indian assortment at £10 to £10 5s., ex ship. There has been a considerable amount of business transacted in Scotch pigs, and prices have advanced to 57s., the market at the close being rather easier.—*Bulletin of the American Iron and Steel Association.*

Microscopic Character of Iron and Steel.—According to Mr. Schott, the different qualities of iron and steel can readily be distinguished by means of the microscope. Thus the crystals of iron are double pyramids, in which the proportion of axes to the bases varies with the quality of the iron. The smallness of the crystals and the height of the pyramids composing each element, are in proportion to the quality and density of the metal, which are seen also in the fineness of the surface. As the proportion of carbon diminishes in the steel, the pyramids have so much the less height.

In pig iron, and the lower qualities of hard steel, the crystals approach more closely the cubic form. Forged iron has its pyramids flattened and reduced to superposed parallel leaves, whose structure constitutes what is called the nerve of the steel. The best quality of steel has all its crystals disposed to parallel lines, each crystal filling the interstices between the angles of those adjoining. These crystals have their axes in the direction of the percussion they undergo in the working. Practically, good steel examined under the microscope has the appearance of large groups of beautiful crystals, similar to points of needles, all parallel and disposed in the same direction.

It is rather singular, that while many journalists appear to have a proper appreciation of the advantages of a diversification of industry, and depict with force and clearness the value of prosperous manufacturing establishments to any section of country, they will, at the same time, advocate a policy that would not only prevent the growth of our great industries, but would inevitably result in the retrogression and decay of such as we have. The St. Louis "Republican" urges the fact upon the attention of its readers, that that city might, in the course of a few years, become the Sheffield of America, if enough capital and enterprise were applied to the development of its superior facilities for the manufacture of steel ware. It shows that in the Shepherd Mountain district, within a few miles of the city, there are exhaustless quantities of ore of the choicest quality for making steel. Well does the "Republican" know, that leaving out Bessemer steel rails, nearly one-half of the quantity of steel consumed in this country comes from abroad, and that this is not owing to the inability of our steel-makers to produce steel of the best quality, for all purposes, or to the incapacity of our people to make all that our country requires, but to the inadequacy of the tariff, or perhaps it would be better to say, to the impunity

with which it is evaded. The "Republican" further urges the establishment of rolling mills for the manufacture of rails in the neighborhood of St. Louis. Now we also believe that Missouri possesses all the resources that are requisite to make it the "black country" of America; but in the present condition of the rail manufacture the promise is not great enough to encourage "the liberal investment of capital" in that direction. A cargo of English rails, 30 lbs. to the yard, have recently arrived at New Orleans, which cost delivered there, all expenses paid, something less than $62, currency, per ton. The total consumption of rails in 1870 in this country was a little over a million of tons; of this quantity 472,403 net tons were imported, and, judging by the importations thus far, the quantity this year will be over 500,000 tons, or enough to keep 20 or 30 large rail mills in full operation. Place these rail mills in Missouri and other Western States, with tens of thousands of workmen necessary to operate them, and the advantages, which are now only sighed for in dreams, will be realized.—*Bulletin of the American Iron and Steel Association.*

Durability and Deterioration of Iron.—The late eminent engineer, Mr. J. A. Roebling, maintained that a good car axle made of good material and finished by the proper heat, by hammering or rolling, is stiffer and stronger than the same axle when again subjected to annealing without hammering or rolling; for, as annealing restores softness, but at the same time reduces cohesion and elasticity, to restore the iron of a brittle car axle fully can only be done by a full heat, with hammering or rolling, which of course reduces its diameter. The opinion, too, that a well drawn out fibre is the only sure sign of tensile strength, is true only when applied to ordinary qualities of bar or rail iron, the case being different with good charcoal irons and with steel. The greatest cohesion is accompanied by a fine, close-grained, uniform appearance of texture, which, under a magnifying glass, exhibits fibre, the color being a silvery lustre, free from dark specks. The finer and more close-grained the texture, the nearer the iron approaches to steel. Wire cables, car axles, piston rods, connecting rods, and all such pieces of machinery which are exposed to great tension as well as torsion and vibration, should be manufactured of iron which not only possesses great cohesion, but also a high degree of hardness and elasticity. The best car axles are those made of soft steel, by Krupp, in Germany, the steel being manufactured from the spathic ore, or natural steel ore, of the celebrated mines at Muessen in Siegen, Prussia. They are considered the safest in cold weather—one of the most important and valuable of qualities—and are seldom known to break.—*Iron Age.*

Hoop Iron Chains.—A chain of the most remarkable texture and workmanship is described in the English journals. The links of this chain, oval in shape, are made from ordinary hoop iron, galvanized and brazed. According to the accounts we have seen of this curious piece of work, the hoop iron is first wound on a reel by a machine suitable for the purpose until the requisite thickness is secured, after which it is passed through a furnace of molten metal. It is then rounded off and finished ready for the brazing, which completes the process. The links are then joined, and between each link is a stay, as in ordinary chains. The strength of a chain thus made is said to be something enormous. In some experimental tests lately made, a 2-inch chain of this pattern was attached to a wrought-iron testing chain of 2½ in. diameter, and on the application of hydraulic power the links of the hoop iron chain were elongated ¼ in., and those of the wrought-iron chain ⅛ in.—the strain being equal to a suspended weight of 110 tons. When the strain had reached 114 tons the testing chain broke, and a careful examination of the hoop iron chain showed that, with the exception of some unimportant openings in the links, which did not seem to have been properly brazed, it did not show any evidence of the extraordinary strain to which it had been subjected. If the results thus described were actually reached, the invention may prove of the greatest practical importance as applicable to the manufacture of chains of unusual strength and small size. We have no information as to whether the process of manufacture is more expensive than that now employed, or whether it is less so—but if the information we have received respecting the strength of these chains be correct, we should say that any increase in cost would be more than compensated by the superior advantages of hoop iron chains for heavy work.—*Iron Age.*

RAILWAY NOTES.

Railroads Developing our Resources.—The effect of railroads upon the development of the resources of the country, and particularly upon the mineral wealth, was never more forcibly apparent than in the production of iron in new regions. Since the first road across the continent was finished, discoveries of both coal and iron ore along the whole route have been made. The Union Pacific Company now smelts its iron ores with its own coal, and proposes to erect furnaces, rolling mills and foundries to supply all its rails, wheels, castings, and other requirements, and this hundreds of miles west of the Missouri river. The North Pacific Railway Company have an abundant supply of ores and fuel upon their line, and have determined to make from these a great part of the rails they will use on that road. Last comes the Southern Pacific, which passes through a country on a portion of the line known to be rich in iron ores. The distance from the manufacturing centres would naturally render the delivery of rails on this line very expensive. But the road develops the supply of its necessities again in this case. A party of capitalists from Pennsylvania, seeing the market before them, have purchased a large tract of land in Alabama containing immense quantities of iron. They are preparing to erect the necessary furnaces and rolling mills, and already offer to supply the Southern Pacific Railroad with all the metal to iron its tracks, and for the construction of wheels, spikes, fish bars, etc., which may be required, for $10 per ton less than they can be furnished from Europe, or any other point in America. Here is direct evidence of the benefits of wilderness railroads, as they are termed, in opening up mineral resources, which, under other circumstances, would remain hidden for years. The road not only brings a population to the soil for its cultivation and agricultural development, but creates industries which

furnish at once a market for its products, and facilities for transporting the surplus to more distant regions. This is the true theory of development for the great area of unsettled lands, and no wiser policy can obtain with the companies now engaged in the construction of the trans-continental lines, and in the projection of lateral branches, than the manufacture of all the articles which enter into the construction of their roads, locomotives, cars and shops. By this means the country along the line will be rapidly settled, and an immense impetus given to the industry of the country, while the laboring classes will be also directly benefited.—*Iron Age.*

THERE is a rather interesting official paper in the last "Gazette of India,' showing all the accidents and injuries to life and limb that have occurred on the 4,581 miles of Indian railway during the past and previous years. Last year there were 69 collisions and 258 cases of running off the line. The collisions do not appear to have been of a very serious nature, the total number of accidents resulting from them being 3 persons killed and 42 injured, 1 death and 30 injuries having been caused by one accident alone. Of the total of these two classes of accidents, or 327, only 16 occurred on the East Indian Railway, while the great Peninsular line, with less train mileage, is credited with 228. The little Punjaub and Delhi line, of 541 miles, is stated to keep up its character as the worst managed line in India—to be improving on it, indeed—the preventable accidents last year being 51 as against 15 in 1869. Of 53 cases of fire, 38 occurred on the Punjaub line; and of 314 cases of running over cattle, 128 were on the East Indian line. On the Bombay and Baroda line a half-grown buffalo caused the death of 11 passengers and the injury of 7. The report explains that the "cattle" run over include camels, wild buffaloes, wild pigs, and several bears and wolves. The actual number of passengers killed in 1870 was 13, and injured 63, or 2.53 per million, by causes beyond their own control and 1.65 through their own misconduct or incaution, which is below the average of the past 8 years. The most curious return is that given of the deaths of passengers occurring in trains or stations. No less than 152 deaths were reported in 1869, and of the 114 reported in 1870, 63 occurred on the East Indian line; 43 happening in the train, the remainder in the stations. Fever, dysentery, and sunstroke are the prevailing causes of death. Except in the case of sunstroke, of which 6 European passengers died in the exceptionally hot weather of 1869, these deaths do not appear to occur at any particular season.

A NEW CAR WHEEL.—A new car wheel under the patent of I. B. Tarr, is being manufactured at the Fairhaven (Mass.) Iron Works, and it is proposed to establish works especially for the production of the new wheel in that vicinity. The superiority claimed consists in greater strength, lightness, and smoothness of the tread. The process of manufacture is described to be substantially as follows: The melted iron after being poured into the mould, is subjected to a pressure of many tons by means of a hydraulic press. All the gases are thus driven off and the iron is rendered more compact, homogeneous, and free from air bubbles, besides being forced into every part of the mould. The wheel comes out perfect in form, and of uniform density and strength. This process, as applied to iron, is precisely similar to that mentioned by Bessemer in his address before the Iron and Steel Association of England, published in our columns some time since, as producing the happiest results in steel. It is, moreover, used elsewhere in this country for the production of particularly fine and sharp ornamental castings for door and other fixtures. Casting under pressure is not a novelty, although its application to car wheels may be, and is likely to prove advantageous to the product.

ANOTHER LINE TO THE PACIFIC.—At the last session of Congress) the legislation necessary to the perfection of arrangements for the construction of another railroad to the Pacific by a southern route was consummated, and under it an informal organization of the Texas Pacific Railroad has taken place. Mr. Marshall O. Roberts, of New York, who subscribed for $111,000 of the Company's stock, was chosen president of the temporary organization, and it is understood that the executive management of the Company, when fully organized, will be confided to that gentleman. The route of the new road will be found, we doubt not, most desirable, and the cost of construction will be materially less than that of any of its competitors. General Fremont, who was present at the informal organization of the Company, is a subscriber to its stock in the amount of $500,000. It is intended, as we learn, to place the bonds of the Company in the market at an early day, work being commenced in the meantime with the funds realized from the stock subscriptions.

THE GREAT RAILROAD LEASE.—At the annual election of the stockholders of the Camden and Amboy Railroad and Delaware and Raritan Canal Companies, held in Trenton, N. J., the question at issue in the election of directors—7 in the Camden and Amboy and 9 in the Delaware and Raritan Canal—was that of leasing or not leasing the works of the United Companies. The directors elected stand 9 in favor and 7 against leasing. As our readers are aware, a lease of the united works had been proposed to the Pennsylvania Railroad Company, which had accepted it. Subsequently a new proposition was made by the Reading Railroad Company, which latter in general terms proposes to take the Delaware and Raritan Canal on a perpetual lease, paying $750,000 per annum, and increasing the amount $10,000 per year, until it shall reach $1,000,000 per annum, which sum is to be paid annually thereafter: and in case these terms are not agreed to, to take all the property of the United Companies, representing $35,245,000 actual cost, to pay 10 per cent. dividends yearly and a bonus of $1,000,000. It has been stated in some of the city papers that the lease with the Pennsylvania Railroad Company had been settled definitely. This is a mistake. The proposed lease is still in the hands of the committee, not fully completed. It is understood that as soon as the terms are agreed upon, the lease will be referred to the stockholders for their approval, after at least 20 days' notice shall be given. We presume from the tenor of the offer of the Reading Railroad Company, that it would be satisfied with the lease of the Delaware and Raritan Canal to facilitate its coal shipments eastward.

THERE are 17 passenger street railway companies in Philadelphia, Pa.

ORDNANCE AND NAVAL NOTES.

THE ITALIAN MERCANTILE MARINE.—The Italian Customs has recently published some tables showing the total number of vessels which have entered and left Italian ports. They were 233,697, with an aggregate tonnage of 17,979,591 tons. The vessels under the Italian flag were 213,580; and those under foreign flags were 18,882. The total number of the crews of these vessels was 518,930 men, or at the rate of 12 men for every vessel. British vessels entered inwards had a collective strength of 40,406 men, which was reduced to 35,564 men for the vessels leaving Italian ports. The crews of French vessels amounted to 56,467 men. The average number of men belonging to every French vessel was 25; to every Russian vessel was 17; to every British vessel was 15; to every Norwegian vessel was 12; to every Austrian vessel was 11; to every American vessel was 10; and to every Spanish, Greek, and German vessel was 9. The proportion per 1,000 tons was 87 men for Austrian vessels; 77 for French; 73 for Spanish; 54 for Dutch; 52 for Greek; 46 for British; 40 for Russian; 39 for German; 34 for Norwegian; and 26 for American. The coasting trade gave employment to 188,034 Italian vessels with an aggregate tonnage of 10,164,412 tons; 1,404 French vessels of 337,480 tons; 419 British vessels of 148,238 tons; 65 Dutch vessels of 22,893 tons; 187 Austrian vessels of 16,265 tons; and 166 vessels of 20,802 tons, collectively under the Papal, Norwegian, German, Belgian, Spanish, Greek, Russian, Danish, Tunisian, Ottoman, Armenian, Swedish, and Portuguese flags. The numbers of passengers who left or entered Italian ports were 1,109,122; 66,427 persons went to and 64,387 arrived from foreign countries; and 13,147 embarked for America.—*Mechanics' Magazine.*

EXPERIMENTS AT SHOEBURYNESS.—Thursday was one of those show-days at Shoeburyness of which the object is to give the visitors as much as possible for their money. The entertainment is required to be of a piquant character. There must be a slice from every dish which Shoeburyness can serve up—a slice well spiced and seasoned, a slice which is beyond no one's powers of digestion. The plain fare of an ordinary working day will not do on a "special-train day." There must be a little 12 in. gun, and a little 9 in.; a *soupcon* of Moncrieff carriage, a flavor of field gun, a spice of segment, and a finish of shrapnel, some life-saving rocket, and a morsel of 7-pounder. The effect on the targets is less considered than the effect on the visitors; and important contributions to the professional knowledge of our engineers and artillerymen are not often made on days like these. And yet such days are not wholly thrown away. They are occasions on which a large number of persons are for the first, and in many cases the only time of their lives brought face to face with the realities of actual practice. Probably no one who has not seen a stout iron target fired at has much idea of what it is like, or realizes the crowded concealment in the bombproof, the moment of expectancy, the earthquaking discharge, the quick patter around of the iron fragments, the run through the dense sulphurous smoke to the targets, the examination of the curious deep hole, the sides of which are too hot to be safely touched. There is a great deal in all this which is interesting, and even exciting, and it is certainly desirable that the interest of these experiments should find its way, beyond those who are professionally engaged in them, to the outer world. The vast importance of these experiments is such that we should be very sorry to see anything done which could in any way reduce such public sympathy and support as they now receive; and, therefore, we should be very sorry to see these occasional gala days at Shoeburyness given up. Nevertheless, it is fair to observe that they are not days on which much real work is done; and to this rule Thursday's experiments were no exception. The main business of the day consisted in practice against two targets, which represented turrets of vessels of the Thunderer, Devastation, Rupert, and Fury class. No. 34 target consisted of a solid 14 in. plate, resting on vertical (9 in.) and horizontal (6 in.) balks of teak backing, with an inner iron skin of 2½ in. plates and the usual iron ribs. No. 35 target consisted of a solid 8 in. plate on vertical 9 in. teak balks, then a 6 in. plate, and then horizontal 6 in. teak balks, with the skin and ribs as in No. 34. Against these two targets were ranged at a distance of 200 yards the three most powerful guns in this country (if we except the single specimen of the 35-ton gun), viz., the 12 in. of 23 tons, the 11 in. of 23 tons, and the 10 in. of 18 tons. Only the first of these was fired on Thursday. One 12 in. Palliser shot and one 12 in. Palliser shell was fired at each target. The superiority of the cord shot to the shell against these very thick targets were fully established by these 4 shots. In both cases the shot penetrated to a considerable depth, while the shells burst apparently, before their penetrative power had been satisfactorily developed. Neither turret was penetrated; the interior being, for all practical purposes, uninjured. The practice against these targets was continued on Friday with the 12 in. and 11 in. guns. On this occasion more injury was done. One shot from the 12 in. broke two bolt heads from No. 35 target, and illustrated the inferiority of those bolts with the *minus* thread and Bascombe washer to the well-tried Palliser bolts, which the Admiralty for some reason or another appear indisposed to adopt. An 11 in. shot struck at the junction of the two plates of No. 34 target, and wedged them open in such a way as to cause considerable damage to the turret; and another round from the same gun made daylight through the same target by driving one of the large bolts before it into the interior. It is not possible to pronounce confidently from such limited data as to the relative powers of resistance of the two structures; but the general impression appeared to be that No. 35 target (with the 8 in. and the 6 in. plate) had rather the best of it. This construction—the details of which, however, admit of considerable improvement—has the further merit of being less costly in the proportion of about 35 to 50. The experiments against these targets will be continued next week. The most interesting feature of the trial was the very satisfactory performance of the new pebble powder. The introduction of this powder has raised the 12 in. gun from a sort of monster howitzer of inferior penetrative capabilities into a plate-piercing gun or enormous power. With R. L. G. powder the initial velocity of the 12 in. shot was only 1,180 ft. per second. It is now 1,300 ft. per second, and the effect of this is that the force of the blow struck has been raised from 5,793 to 7,030 foot-tons—or, in other words, the penetrative power of this gun is now as great at 1,000 yards as it formerly

was at the muzzle. The 11 in. gun, although possessing the same power of penetration—measured in terms of the "energy' per inch of the shot's circumference—is in total power slightly inferior to the 12 in. as 6,415 is to 7,030. But on Friday the 11 in. was rather more lucky in its hits, and made rather a greater show. The increase of power of all our heavy rifled guns due to the introduction of pebble powder is very considerable. The velocities of the guns have, we understand, been increased as follows :—the 12 in. by 120 ft. per second ; the 10 in. by 85 ft. : the 9 in. by 80 ft.; the 8 in. by 85 ft. ; the 7 in. by 90 ft. To any one acquainted with the subject the force of these figures will be apparent. How in face of these results, coupled with the fact that these increments of velocity are obtained with actually less strain upon the gun, any one can be found seriously to argue against the speedy supply of pebble powder we are at loss to understand. *Habitués* of Shoeburyness at all events were able to appreciate the tangible evidence of the efficiency of pebble which was afforded by the magnificent, and we believe unparalleled penetrations which were obtained through its agency on Thursday and Friday. And if the impression which the *habitués* derived was conveyed to some of the illustrious visitors who were present, last week's experiments, if they teach nothing else, will not have been thrown away.—*Pall Mall Gazette.*

A French Soldier's Kit.—M. Grimaud de Caux has proposed to the Thiers government the introduction of a new kind of knapsack, half the thickness and double the length of the one now in use in the French army, and which the soldier might wear either on his back or on his breast. This modification offers some advantages even in battle. The man in this case has his knapsack before him ; and when the fire of the artillery is silenced he may advance upon the enemy to a distance of 150 yards. Here he lets down the longitudinal blade which is contained in the knapsack, so as to make the latter rest upon it, thus making, intantaneously, a kind of breastwork, impenetrable to the bullet, and from behind which he may fire, supporting his musket upon it so as to have a sure aim. The enemy's bullets will mainly fall on the knapsack, or on a kind of metal shade with which M. Grimaud provides the soldier's kepi as a protection for the face. The projectiles will also be averted by the numerous folds of the tent canvas, which hangs like an apron from the bottom of the knapsack. After the battle, whether there be a victory or retreat, a camp has to be pitched. Under the present system, the *tentes-d' abri* are formed, occupying a very small space both in surface and altitude, and only allowing sleeping-room to the 4 men who have contributed their share to the tent. The cooking is done outside with a very precarious and smoky fire, the materials for which are not always at hand, and which cooks the victuals badly and slowly, especially when there is wind or rain. The whiteness of the tents, moreover, reveals to the enemy the place of the bivouac. M. Grimaud's plan does away with or greatly diminishes all these inconveniences. If the halt be only momentary, the new long knapsacks may in a few minutes be placed in rows, supporting each other, so as to form a shelter for 12 men. If the encampment is to last some time the metal shade will serve the soldiers for digging a fireplace, with its requisite gutters ; meanwhile, the 12 knapsacks of the squad are placed upright and fixed, while the tent canvas is drawn over them so as to form a complete shelter. The kitchen fire is concealed from the enemy ; the smoke is less intense, and swept away by the draught. M. Grimaud states that the first idea of this plan was conceived by the Polish General, Mieroslawski.

Messrs. John Elder & Co. recently launched from their shipbuilding yard at Fairfield, Govan, an iron screw steamship of 2,789 tons, B. M., and 600-horse power nominal, for the Royal Mail Steam Packet Company of London. The vessel has been designed and constructed for that Company's service between Great Britain and the West Indies, and is of the following dimensions : —Length over all, 358 ft. ; breadth, 40 ft. ; depth moulded, 35 ft. Her accommodation for passengers is of the most complete description. Besides providing comfortable accommodation for 75 second class, and 50 third class passengers, she is furnished with cabin and sleeping apartments in the highest style of elegance and comfort for 270 first-class passengers. This vessel is similar in construction to the Elbe, launched by the same firm 18 months ago, and which has proved so successful, and also to the Tagus, launched by the same firm in January last, and which left Greenock for Southampton on Thursday afternoon. As the ship left the ways she was gracefully named the Moselle by Miss Marshall, of London.—*Engineer.*

Iron-clad Building in the Golden Horn.—The "Levant Herald" says that on the 25th ult., the ceremony of lifting the sternpost of the Mukat-demiheigher, the first iron-clad—we may say, indeed, probably the first iron ship - laid down in Turkey, was successfully performed in the presence of the Minister of Marine, the members of the Admiralty Council, and a large company of other official spectators. This vessel is being built at Tershaneh, from drawings and specifications furnished by Mr. Reed (late Chief Constructor to the British Navy), and is sister ship to the Fati Bulend, built at the Thames Iron Works. Her dimensions are as follows : Length between perpendiculars, 235 ft.; breadth at water line, 38 ft.; breadth at battery, 42 ft.; tonnage (builder's measurement), 1,601; draught of water, mean (deep), 17 ft. 3 in.; engines, nominal, 500-horse power. The Mukat-demiheigher will be armed with 12½-ton Armstrong guns, enclosed in a central box or battery, which, as the dimensions show, projects out 2 ft. on each side, something like a bow window. This arrangement has enabled Mr. Reed to realize his favorite theory of "all round fire," with ample accommodation for working ropes, etc., which he maintains has never yet been satisfactorily realized in a turret vessel, though, perhaps, the nearest approach was the ill-fated "Captain," designed by Captain Coles. The thickness of the armor plates on the central box of the ship now building at Ainali-kavak, will be 9 in. and 6 in., supported by a backing of teak, 9 in. and 12 in., behind which is worked a "double skin," and a framing of very strong scantling. The armor belt beyond the "box" extends to a depth of 4 ft. below and 2 ft. above the water line, and will be of an average thickness of 5 in. The decks at the ends of the ship and over the battery, are entirely covered with iron plates, and a complete watertight inner bottom is worked for nearly the whole

length of the ship. Besides which, she has the advantage of drawing no more than about 17 ft. water—some 6 or 8 ft. less than the frigates of the English Navy.

If any additional testimony is required in support of Mr. Brassey's proposal to subject the adjusters of compasses to an examination before allowing them to exercise their calling, we have it in the evidence of the captain of that splendid vessel, the Queen of the Thames, recently wrecked near the Cape of Good Hope. He states that, in his voyage out, the compasses were never correct for four-and-twenty hours together; that one would be pointing south, another west, and another northeast, and that although the ship was swung at Melbourne, and a card of deviations supplied to him, his daily observations showed it to be unreliable and totally at variance with the course made good. In this evidence he was confirmed generally by the chief officer and also by the second officer. Now, even while remembering that all iron-built ships are more or less liable to variations in their magnetism, it is difficult to understand such variations in the compasses as are here described, if they had been properly adjusted, more especially after the re-swinging of the ship at Melbourne, and one is forced to the conclusion that, in this, as in many other instances, the adjustment has been improperly made.—*Mechanics' Magazine.*

HOLMES' STORM AND DANGER SIGNAL LIGHT.—Some practical experiments of great value have recently been tried at sea with this new light, with a view of testing its powers as applied to ships' signals. On the 5th of this month the steamship St. Magnus, when two miles off Aberdeen harbor, upon her voyage north, cast overboard at 11.15 P. M., one of the lights to illustrate the life-buoy service; the effect of the light being viewed from Aberdeen pier. The intensity and steady burning of the flame produced upon contact with the water was most remarkable, illuminating the sea for a considerable distance around and burning upon the surface of the water with a brilliancy scarcely inferior to that of the lighthouse, as viewed from the deck of the steamer at some five or six miles distant. This light continued to burn for over an hour. At 11.20 P. M. a second signal light was exhibited from the after peak of the St. Magnus, and such was the power of the light thrown off that the captain of the Queen steamer reports, on passing the St. Magnus at a distance of two miles, the ship was almost invisible from the glare of light which surrounded her, and, being unaware of the nature of the experiment, at first feared she was on fire. The light from the peak of the St. Magnus was distinctly visible at a distance of over 13 nautical miles, and it continued burning until 3.50 A. M., more than three hours. Other experiments made with this new signal light during very stormy weather at Kirkwall, have been equally satisfactory, and go far to establish the value of the light for marine and signal purposes.—*Mechanics' Magazine.*

AMERICAN FIRE ARMS IN EUROPE.—The favor with which the improved patterns of American firearms regarded in Europe bids fair to give them the preference over all forms of rifles and muskets now in use in the armies of the great powers, not excepting the Chassepot and needle gun, the Sneider and the new English arm, the Martini-Henry. During the late European war we exported to France from this port not less than 600,000 muskets, but these shipments are of but trifling importance compared with the heavy orders which our manufacturers have received for the most approved patterns of rifles which have received the approval of the American government and were subjected to practical and satisfactory tests in the late civil war. Among the new American rifles, the Remington seems to be the most popular abroad as well as at home. The first European order for the Remington rifle was received some five years ago from Denmark, to which country 42,000 were shipped. Since then Sweden has taken 30,000; Cuba, 50,000; Egypt, 110,000; Rome, 10,000; Japan, 3,000; France, 150,000, and Greece, 30,000. The German government has not ventured the experiment as yet, but it is stated, on high military authority, that the needle gun is not entirely satisfactory, and that if the proposed re-armament of the German forces is carried into effect, the American arm will be given a chance to compete with those of European manufacture. Beside the Remingtons exported, we have sent abroad many thousand stands of old muskets, 200,000 Berdan rifles, and upwards of 60,000,000 cartridges. We have also sent abroad a considerable amount of ordnance, heavy and light. Altogether, our shipments of arms to Europe since the commencement of the late Continental war, are said to have reached the following enormous totals: 500,000 carbines and rifles, 20,000 revolvers, 214,247 Remington arms of various kinds, 300 Parrot guns, 36 Gattling batteries, and over 100,000,000 cartridges. Is is to be regretted that commerce in war material is not at an end forever, but while there exists a market for such goods, which must be supplied from some source, it is gratifying to our national pride to know that the skill of our inventors is recognized and appreciated abroad, and that American arms are considered superior to the best of those made elsewhere. The Old World cannot teach us much that is worth knowing about working in iron, whether the article to be made is a steamship, a bridge, or a repeating rifle.—*Iron Age.*

THE BONETTA, another of the new class of gunboats, has just been launched from Messrs. Rennie's shipbuilding yard at Greenwich; the sister boat, the Arrow, was completed a few weeks since. These boats will each carry one 18-ton gun, are built on the same principle as the Staunch, and are specially designed for coast and harbor defence.—*Mechanics' Magazine.*

ENGINEERING STRUCTURES.

THE GREAT BRIDGE AT ST. CHARLES, MISSOURI.—Of this structure, just completed, we shall give a full description in our next number. The following brief statement of the dimensions of the work we received by favor of the chief engineer, C. Shaler Smith:

The St. Charles Bridge is composed of seven spans, varying from 306 to 321½ ft. in length, and 4,800 ft. of iron viaduct approach.

The piers are of masonry, and the depths of the foundations are respectively 76 ft., 73 ft., 71 ft., 68 ft., 54 ft., 23 ft., 7 ft., and 22½ ft. below water level. There are three spans over the mid river, 90 ft., above low water, and admitting of 900 ft. shift of channel.

The rise and fall of the river at this point is 40 ft., and the depth of scour, 43 ft.

During the progress of the work the river attempted to change its bed—cutting in over 1,400 ft. just above the bridge. The successful controlling of the Missouri river was probably the most difficult part of the undertaking.

AN INDIAN SHIP CANAL.—The proposition to construct a ship canal, connecting the Gulf of Manaar with Palk's Strait, which has been so strongly urged by Sir John Elphinstone, has been brought under the notice of the Secretary of State for India, by a deputation from the East India Association, which was permitted to wait upon the the Duke of Argyll on Wednesday last.

The object of the work is to form a navigable channel between the mainland of the Indian Peninsula and the Island of Ceylon, and thereby to avoid the circumnavigation of the island, and some 360 miles distance. The conformation of the obstacles which now separate the Gulf of Manaar from Palk's Strait is extremely curious. On the north-west coast of Ceylon, and belonging to it, is the Island of Manaar, and from this there extends for a distance of 25 miles a line of rocks and shoals, to the Holy Island of Rameseram, on the Indian coast, and separated from it by about a mile of sea, strewn with sandstone boulders rising 8 ft. above the water level. A good many years ago, by removing some of these boulders, and blowing up others, a crooked channel was created, which was kept clear by the current running through the Palk's Strait, but which was totally unfit for general navigation.

Along the whole of the coast, from Tuticorin to the Island of Rameseram, the shore is lined by a row of small islets connected by sand-banks, on the other side of which the surf of the Gulf of Manaar breaks, and which landlock the channel lying between them and the mainland. The scheme of Sir John Elphinstone is to cut a canal through one of the sand-banks for a distance of 250 yards, giving access to a completely protected harbor 16 square miles in extent, and further to make a short ship canal across the Tonitory Point, a small promontory which stretches out toward Rameseram. This latter work would give direct access to Palk's Strait, and thence to the Bay of Bengal. The estimated cost for the work is £90,000.

Another important advantage pointed out in connection with this project is the substitution of an excellent refuge, instead of the dangerous and exposed harbor of Galle. This harbor, beset with rocks, and open to the full swell of the Southern Ocean, is also insufficient for accomodation, and the difficulties and expense connected with improving it are so great, that the idea is for the present abandoned. But with the proposed canal, an ample roadstead would be provided in the Gulf of Manaar, on the direct route the ships would take on their way through the new channel.

The commercial prospects of this work are based upon the trade statistics of Calcutta and Madras, which at present amount to 2,000,000 tons a year. Of this about three-fourths would pass through the canal, in addition to some 200,000 tons of local coasting trade, so that there would be some 1,700,000 tons a year upon which to take toll. The tonnage rate proposed is 1½d., which would yield on the above amount about £10,000 a year. This may be an over-estimate, but the advantages to be derived from the improvement are so great as to make the matter of pecuniary success of secondary importance.

The work, which has so long been urged upon the Government, outside as well as within the House of Commons, has, in common with many other great Indian questions, been shelved, or, at least, received with the languid interest which characterizes most Indian debates, great or small. Now, however, that it is being more strenuously urged, and especially now that private enterprise is prepared to find capital to execute the work, there appears a reasonable chance of Sir John Elphinstone's efforts being crowned with success.

THE NEW PIER SYSTEM FOR NEW YORK.—General McClellan's report makes known the plan adopted by the Commission for the piers of our city.

As stated by the Commissioners, the main feature of the system now devised, is a wide river street, varying from 150 to 200 ft., and completely environing the water front. This will afford ample room for the movement of freight, and uninterrupted transportation by rail. Of course, due regard must be had for existing rights. For example, at Fulton Market, the lease of water front has ten years to run. But the fact is obvious that the new constructions may not even approach a completion while the present generation survives. All the new river front will be lined with a solid wall of masonry, probably granite, in combination with a concrete called Beton, which is composed of Portland cement and broken stone, and has the quality of hardening when immersed. The endurance of this substance has been fully tested in the harbors at Cherbourg and Algiers, also on the Suez Canal. This sea wall or bulkhead will cost, according to estimates, something like $2,500,000 per mile, and the depth of water alongside will be not less than 20 ft., sufficient to float the heaviest loaded merchantman. From the sea wall, projecting into the river, will be a series of piers, most of which will be of wood, of the most substantial character, but a limited number will be constructed of stone or iron. The piers will vary in length, according to the width and location of the channel—from 300 to 500 ft. long, and from 60 to 100 ft. wide, and will be built with iron columns, or stone, or wood, according to circumstances. The column at the head of the pier is of granite, its entire height, and extending the full width of the pier, in order to guard the structure from damage by concussion from vessels and heavy drift ice. The other columns are of iron, having an interior diameter of 6 ft., in order to give room for the men while they are at work inside sinking them to the bed rock. When in position they will be filled with rock and hydraulic cement, so as to form solid columns. There will be rows of three iron columns abreast, one on each side of the pier, and one in the middle, between them, supporting the trestle-work and flooring. Of course, if it is deemed necessary, solid stone columns can be used instead of the iron, or part granite and part Beton, as in the bulkhead. The bulkhead may also, if necessary, be made entirely of granite. The piers have been so arranged that the tide will act as fully as possible in carrying away the mud in the slips, and tend to decrease the cost of dredging them by machinery. The distances between the piers will be 200 ft. It is also intended

to cut the sewers through the stone bulkheads and extend them by large pipes under the piers to or near the pierheads so that they may not obstruct the ships with their deposits. Iron mooring piles will be placed on the piers for the accommodation of shipping lying alongside.

THE DETROIT TUNNEL.—The building of the great sub-fluvial tunnel under the Detroit river, the completion of which is now assured by the practical consolidation of the Michigan Central and Great Western Railroads, will be the greatest engineering work of its kind ever projected in this country, if not in the world. The lake tunnel at Chicago, though of considerable length, is of small capacity, and will bear no comparison with that to be built at Detroit, while those carried under the river at the former city, though of good size, are so short as to be in all respects inferior to the present undertaking as engineering works. In the magnitude of the plan of its construction, in the capacity it will have under water, and in the amount of business which will pass through it, the Detroit tunnel will certainly have no rival upon this continent until the long contemplated scheme of uniting New York with the New Jersey shore by a tunnel under the Hudson is carried into effect.

The plan finally adopted by the tunnel company for the construction of the great work is substantially the same as that prepared some months since by Mr. Chesbrough, of Chicago. The length from the Detroit to the Canada portal will be 8,568 ft. It will be built in two separate parts, with a view to diminishing the amount of excavation necessary, and lessening the liability to accident, and also for the important consideration that, if an accident should occur in one-half, the other would still be available for the passage of trains. The parallel tunnels will be cylindrical in form, and will be 50 ft. apart. The interior diameter of each is 18½ ft., and at all points under the river the shell of masonry will be 2 ft. in thickness. The excavation will be made through a stratum of hard clay, and it is not intended that it should at any point come within less than 20 ft. of the surface of the bed. Whenever it is found that the distance is less than this average, clay will be filled in to a sufficient depth to avoid the possibility of accident. In addition to the main tunnels a small drainage tunnel, with an interior diameter of 5 ft., will be built considerably below the main lines and midway between them. This will be first constructed, in order to drain the main tunnels while the work progresses, as well as afterwards, and also to fully develop the character of the soil at the commencement of the work. The grade of the transit tunnels is one in 50 at each end, with 1,000 ft. of level line under the river. The estimates for excavation and masonry are as follows:

	Cubic yards.
Excavation in open cutting.....	200,000
" " tunnels.....	233,000
Brick masonry (exclusive of drainage tunnel).....	68,000
Stone masonry.....	3,700

A working shaft, 10 ft. in interior diameter, will be sunk on each bank of the river midway between the main tunnels, and connected with them by lateral drifts, each with an interior diameter of 9 ft. It is estimated that, without sinking any working shafts in the river, the work can be completed within 2 years. The entire cost of the tunnel and approaches, including a permanent double track of steel rails, right of way at the ends, etc., will amount to $2,650,000. The work of constructing this important international tunnel will be undertaken by a company chartered by the Canadian Parliament under the name of the Detroit River Transit Company, and such action as is needed to secure incorporation under the laws of Michigan has already been taken. This Company is organized on a basis of $3,000,000 capital, and is authorized to issue stock and bonds, and to consolidate with any company organized for the same purpose under the laws of Michigan. The money for the undertaking will mostly be obtained abroad, either stock or bonds being placed in the English market, and funds obtained at a comparatively low rate of interest, not over 6 per cent. The two railways interested in its completion, the Michigan Central and Great Western of Canada, will probably guarantee the payment of interest on such stocks or securities as may be issued, and the advantage gained for the lines in doing away with the costly ferriage system now established, and in the increased certainty and speed of shipment across the river, will certainly more than repay the cost of the tunnel in a few years. The enterprise is one of great magnitude and importance, and its completion will mark the beginning of a new era in American railroad engineering.—*The Iron Age.*

THE NESQUEHOMING TUNNEL.—It is not generally known that a tunnel which, for scientific engineering, and economy, speed and durability of work, is not surpassed by the Mount Cenis or Hoosac tunnels, is being driven by the Lehigh Coal and Navigation Company, of Pennsylvania. The location of the tunnel is near Summit Hill, Pa., and it is being driven for the purpose of doing away with the Switchback railroad. It is a continuance of an old mining tunnel known as No. 7, and when completed will be nearly a mile in length. The Company adopted the location as the most central and desirable, and the old tunnel having been driven 1,500 ft. to the Mammoth Vein, made a considerable less distance to be cut. Although little known by the public, engineers of celebrity state that the science of tunneling is here illustrated under the most perfect conditions, and that the record of the work is eagerly examined by experts, both here and in Europe. The work, to describe the whole of which would require too much space, was at the beginning prosecuted by hand drilling, but as soon as the Burleigh drills were introduced, they were adopted after trial, and went into operation March, 1870, since which time they have given great satisfaction. The tunnel is driven through the coal measures, cutting each vein known in the region, and after passing through them, it penetrates an intensely hard conglomerate, leaving which, it enters red shale.

A brief description of the Burleigh drills used will be interesting. The drills are driven by condensed air, which is pumped by six 20-horse power steam engines into a large iron receiving tank, from which it is conducted into the tunnel through a 6-in. pipe of cast iron, and is distributed by hose to the 3 carriages which support the drills. These 3 carriages support the drills used for the heading and the first and second

enlargements. The heading carriage supports 5 drills, the first and second enlargements each having 3. Motion is given to the drills by the action of condensed air in the cylinder, the piston of which is connected directly with the drill. Their working is far superior to that of any previous process, a 3-in. hole having been driven in sandstone in 11 min., while the average progress in the hard conglomerate rock is 7 ft. per hour. The heading is now in the red shale, and is proceeding at the rate of 35 ft. per week.

Work is soon to be prosecuted from both ends of the tunnel, and the boiler and blowing engines are erected and in readiness at the north portal. When under full headway, about 60 ft. per week will be made, and at that rate the two headings will meet in September. The enlargements follow upon the heading, and it is expected that trains will run through by January, 1872. The work, when completed, will save great expense and delay in moving trains on the Lehigh Navigation Co.'s roads, and will be quite as much an object of curiosity to tourists as was the famous Switchback railroad, which has been visited by many thousands.—*Iron Age.*

NEW BOOKS.

REPORTS OF THE U. S. COMMISSIONERS TO THE PARIS EXPOSITION OF 1867.

These reports are now gathered into a collection, forming a set of six octavo volumes bound uniformly. The editing of the whole has been in charge of Mr. Wm. P. Blake, the commissioner from California.

It is rare that Government reports contain so much that is valuable to science, as is collected in these volumes.

FRAGMENTS OF SCIENCE FOR UNSCIENTIFIC PEOPLE: A Series of Essays, Lectures, and Reviews. By JOHN TYNDALL, LL.D., F.R.S. (Longmans, 1871). For sale by Van Nostrand.

Professor Tyndall has been well-advised by his American friends to give the world a companion volume to Huxley's admirable "Lay Sermons." The only fault we can find is with the expression that these Fragments are for unscientific people, which neither their history nor character justify. Here we have lectures delivered in the Senate House at Cambridge, before the British Association, and contributions to philosophical periodicals, embracing discussions on Miracles, Materialism, the Constitution of Nature, etc., and, so far from being suitable for unscientific people, we think any reader may take it as a fair test of the question whether or not he is a scientific person, that he fully comprehends the meaning and scope of these Fragments.

The volume contains fourteen papers, the best things that Dr. Tyndall has spoken and written in the last ten years; and, as all of them have been published already in some form or other, and have attracted much public notice, it is our duty merely to welcome their conjoint appearance in a volume that may be read over and over again with increasing delight by all who are, or are capable of becoming, "Scientific People." Though professedly "detached fragments," these essays and discourses form a very harmonious—we had almost said complete—system of physical philosophy. Some of the papers, such as the well-known ones on "Radiation" and "Dust and Disease," are of intrinsic scientific value, while others are of high speculative interest. We know no writings where larger or juster ideas are embodied regarding the processes of Nature, or the laws of energy, whether as affecting the stellar systems, or the ultimate material atoms.

CURRENT FALLACIES ON NAVAL ARCHITECTURE. By E. GARDINER FISHBOURNE, C.B., Rear-Admiral, R.N. London: E. and F. N. Spon, 48 Charing Cross.

This treatise, though only extending to twenty pages, is at the present time, when the Admiralty appear to be "at sea" respecting the stability of our iron-clads, very opportune. Coming as it does from the pen of one who is not only a naval officer of great experience, but who has also been deservedly considered one of the first authorities upon naval architecture, it especially recommends itself to the careful perusal of all who are interested in this important question. It is to a certain extent a sequel to the author's treatise on the loss of the Captain, which was noticed in "The Artizan" a few months ago. In the present work Admiral Fishbourne gives, by the aid of diagrams, a simple exposition of the various points there treated upon, together with an explanation of the scientific terms used, so as to bring the treatise within the comprehension of a non-professional reader. A perusal of this pamphlet, will, we feel confident, be not without advantage, both to professional and non-professional men, who are interested in the future of our navy.—*The Artizan.*

THE THEORY OF GUNNERY. By P. ANSTRUTHER, Major-General. London: E. and F. N. Spon, 48 Charing Cross.

This is a short brochure addressed to the Institution of Civil Engineers, and calling in question the correctness of the various mathematical works and manuals at present used as guide-books in the Government military schools. The author appears to desire that scientific men, free from prejudice, should test the accuracy of his conclusions, and therefore appeals from the military to the civil engineer. Thus in paragraph 21 he says:—"We are obliged to appeal to the civil engineers, because the military engineers have not the means, the artillery have not the will, to try the experiments required." This is, no doubt, complimentary to civil engineers, but we doubt if many, even if any, gentlemen belonging to that body could afford not only the means, but the time required to carry out experiments such as the author desires.—*The Artizan.*

ELEMENTARY PRINCIPLES OF CARPENTRY. By THOMAS TREDGOLD. Revised from the orginal edition and partly re-written by JOHN THOMAS HURST. London: E. and F. N. Spon, 48 Charing Cross. For sale by Van Nostrand.

We gladly welcome a new edition of this favorite standard work. Since the last edition, as our readers are no doubt aware, vast strides have been made, both in the knowledge of the best methods of construction of large works, and also in the discovery of new species of timber, some of which are peculiarly adapted for special purposes. Thus as regards bridges, the Americans have employed timber for their construction to a very large extent, in consequence of the cheapness of the ma-

terial, and in their endeavor to attain this object they have given us some very fine new examples of the principles of carpentry. Then, again, our knowledge of the varieties of timber has been very much enhanced by the excellent specimens forwarded to the various international exhibitions from our colonies and other parts of the world, where but little was heretofore known of their qualities. We have, we fear, yet to find timber thoroughly suitable for piles or sleepers in tropical climates, but much has been done, especially with the assistance of artificial preservation to ameliorate the excessive destruction, to which earlier works constructed with improper materials were liable. Upon the subject of timber, the present edition contains a great deal of valuable information, which, we consider, will be especially valuable to engineers engaged abroad.

TABLES FOR CALCULATING EXCAVATION AND EMBANKMENT OF REGULAR AND IRREGULAR CROSS SECTIONS. By E. C. RICE, C. E. St. Louis: R. P. Studley & Co. For sale by Van Nostrand.

All engineers whose labors involve earthwork calculations know the value of good tables. The set before us was evidently devised by one who has learned through experience what was most to be desired. The tables cover all the cases of ordinary practice, and are mechanically so constructed as to save the eyes and the patience of him who must use them. Each table is printed on a single page 9½ by 13 in., and in type of good size.

This merit does not belong to most of the tables with which we are familiar.

Mr. Rice has prefaced his book with an elucidation of his plan, and at the same time a proof that it is based on the "Prismoidal formula."

A REPORT ON THE BRIDGES ACROSS THE OHIO RIVER.

This is a pamphlet of 74 pages, containing a report of three engineers, Gen. Warren, Gen. Weitzel, and Col. Merrill, made by order of Government, upon the bridges of the Ohio River. The object was to determine whether the present or proposed structures were likely to interfere with the free and safe navigation of the river.

The minute details of the various measurements, and observations upon currents and their effects, are not only interesting, but afford highly instructive reading.

INSTRUCTIONS FOR THE MANAGEMENT OF HARVEY'S SEA TORPEDO. London: E. and F. N. Spon, 1871. For sale by Van Nostrand.

The recent trials with Harvey's sea torpedo gave undoubtedly some very promising results, which will probably warrant the introduction of the weapon into the service to some extent. The book of instructions published by Captain Harvey, or under his direction, must be regarded, however, as somewhat anticipatory, especially that part of it devoted to the management of the torpedo vessel, and the dangerous weapon it directs. The hand-book comprises a very full description of the torpedo, with numerous drawings, showing its construction in every detail, together with particulars of loading it, and instructions for its management. With equal minuteness is described the method of handling it after it has been committed to the deep, and laid on the trail of a fated vessel. Captain Harvey considers that the torpedo ship best suited for the purpose is a vessel of about 400 tons burden, and 150 ft. in length, and built so as to insure the greatest possible speed, which is one of the leading requirements for such a service. With a vessel like the one he describes, Captain Harvey considers that he could manœuvre at his pleasure about a hostile fleet, threading his way between unfriendly vessels, and exploding torpedoes with fatal effects beneath them, now closing up right alongside, now taking as wide a berth as possible, that is to say, some 40 or 50 fathoms, according to the length of the rope. Of course darkness would, whenever practicable, be taken advantage of, for these hostile demonstrations, and it is stated on the strength of blockade running experience, gained during the American war, that comparatively little risk would attend such an operation. For our part, we differ entirely in this opinion, and we do not consider it possible for a vessel of the size and outline recommended for this torpedo service to manœuvre unseen close by an enemy's ship, no matter how great might be the darkness; and it is certain that the service would be one of the most dangerous connected with marine warfare. Not that such vessels would ever want for hands; during the American war there were always enough to be found as volunteers for those marine forlorn hopes, from which so few ever returned. There was but small chance, indeed; for those who luckily escaped the explosion were exposed to drowning, or the hail of fire, for which the torpedo explosion was a signal. The danger in such a boat as Capt. Harvey proposes, would probably be less than in one of the small nearly submerged craft, which carried the torpedo on the end of a spar, and ploughed its way slowly through the water by the efforts of the crew, who worked some mechanical contrivance for propulsion, until the object of attack was reached, and the collision occurred.

Nevertheless, in looking over the illustrations that accompany the "Tactics," one is struck with the quiet indifference of the threatened ships, which we are led to imagine would permit a hostile vessel, half their own size to approach within easy rifle range without sending her to the bottom. If it was stated that such an operation was attended with equal chances of destruction to destroyer and destroyed, we could understand it; but, on the contrary, it is hinted that the service would not be an exceptionally dangerous one.

These same illustrations, executed by Messrs. Kell Brothers, are excellent sketches in lithography, especially the last one, which represents the annihilation of a whole fleet of armor-clads by a number of torpedo ships, which deal death and destruction around, and apparently with as much security as if they "had the receipt of fern-seed, and walked invisible." If this picture were only historical instead of anticipatory, how interesting it would be!

The publishers have spared no pains in the style of finish of Capt. Harvey's book, which is, indeed, of interest and of value; but it is a pity that it is so carelessly and crudely written.—*Engineering.*

A MANUAL OF THE PRINCIPLES AND PRACTICE OF ROAD MAKING. By W. M. GILLESPIE, LL. D., C. E. Tenth edition, with large Addenda by CADY STALEY. A. M., C. E. A. S. Barnes & Co., New York. For sale by Van Nostrand.

Gillespie's Roads and Rialroads is the title by which this excellent work has been long known to

engineers and surveyors, and its merits are so well understood that no lengthy comment can be of any special use. It is sufficient to say that no other work that we are acquainted with answers the same purpose.

The author, besides his peculiar qualifications as an engineer, possessed also those of an able instructor, and was thus doubly prepared for the task of writing on a subject of which even the technical schools teach almost nothing, but of which the learners are very numerous.

The Addenda which appear in the present volume, are prepared by a careful hand from the notes of the late author.

They relate chiefly to measurements of earthwork, railway curves, and bridges. On the first two of these subjects the treatment is of the clearest possible kind, and as complete as in the best treatises on these subjects.

In bridge building the wants of the common road builder have only been regarded, but the same concise method of statement characterizes the section.

Some brief articles on tunnels, grades, and methods of drawing specifications, will prove valuable to some of the many classes of readers that are certain to require and consult the book.

LIVES AND WORKS OF CIVIL AND MILITARY ENGINEERS OF AMERICA. By CHARLES B. STUART, C. E. New York: D. Van Nostrand.

This work possesses a twofold value for American readers. First, inasmuch as it affords a correct, though concise, account of the personal labors of the men who have become identified with the great engineering achievements in this country; and, secondly, in the history of the works themselves.

We are attaining a high rank as an engineering people. In some fields of labor our recent exploits have surpassed all that has been heretofore accomplished. How we have progressed from small to great, the history of our great improvements tells us. To whom we are largely indebted for the high and growing reputation of American engineering, Mr. Stuart tells us in his biographies.

How well both departments of the history are treated, the present number of the MAGAZINE bears testimony in the sketch of Benjamin H. Latrobe.

The work is handsomely printed on tinted paper, and embellished with steel engraved portraits.

The names of the engineers forming subjects for the present volume are Major Andrew Ellicott, James Geddes, Benjamin Wright, Canvass White, David Stanhope Bates, Nathan S. Roberts, Gridley Bryant, Gen. Joseph G. Swift, Jesse L. Williams, Col. William McRee, Samuel H. Kneas, Capt. John Childe, Frederick Harbach, Major David Bates Douglas, Jonathan Knight, Benjamin H. Latrobe, Col. Charles Ellet, Jr., Samuel Forrer, William Stuart Watson, and John A. Roebling.

An Appendix contains a description of the Union Canal, in Pennsylvania, in 1830, and the First Eight-wheel Locomotive.

MISCELLANEOUS.

A COMPARISON of the temperature and quantity of rain in the spring months for the 10 years previous to 1871, and also a summary for the spring of 1871, in the city of New York, by Oran W. Morris.

Year.	Mean Temperature.	Quantity of Water.
1861	49.46°	17.43 in.
1862	49.09	10.52 "
1863	49.13	16.04 "
1864	51.90	10.66 "
1865	54.39	18.02 "
1866	49.61	10.83 "
1867	45.29	12.26 "
1868	44.97	17.30 "
1869	43.99	13.16 "
1870	50.12	12.92 "
Mean	48.79°	13.91 "
1871	53.21°	13.95 "

The spring of 1871 was 4.42 deg. warmer, and 0.04 in. more water fell than the average for the 10 springs before.

The warmest spring was in 1865; which was 5.6 deg. warmer than the average. Spring of this year (1871) was 4.42 deg. warmer; a difference of 1.18 deg. between the extremes.

The coldest spring was in 1869, which was 4.8 deg. colder than the average, and 9.22 deg. colder than that of 1871.

The greatest quantity of rain fell in 1865, and the least in 1862; a difference of 7.5 in., and 4.11 in. more than the average.

The warmest day in the series, including 1871, was on the 30th day of May, 1871, 81.73 deg.; the coldest was the 3d day of March, 1868, 6.26 deg.

The warmest day in March was the 3d, in 1861, 62.53 deg.; in April the 22d, in 1866, 73.06 deg.; in May the 30th, in 1871, 81.83 deg. The coldest day in March was the 3d, in 1868, 6.26 deg; in April the 5th, in 1868, 28.06 deg; in May the 16th, in 1871, 38.40.

The highest degree of the mercury in the thermometer was 89 deg. at 3 P. M. of the 30th of May, 1871.

The observations noted above were made at 7 A. M., 2 P. M., and 9 P. M., on the same instruments, the thermometer in the shade, and a free circulation of air, and the readings of the barometer are reduced to 32 deg. Fahrenheit.

The spring of 1871 had the mean of the barometer, 29.843 in.; the maximum was April 24th, 30.368 in.; the minimum was March 27th, 29,318 in. The mean of each of the months was, in March 29.888 in.; April, 29.778 in.; May, 29.863 in. The mean humidity was 61.59 deg., a little more than half saturation. The quantity of rain was, for March, 5.6 in.; for Aril, 3.45 in.; for May, 4.9 in. The whole amount for the spring 13.95 in., a little more than the average for 10 years.

The thermometer indicated a mean for March of 44.45 deg.; for April, of 53.33 deg.; and for May, of 61.84 deg. Mean for the spring, of 53.21 deg. It was at the highest on the 30th of May, 88.5 deg., at 2 P. M.; the lowest, on the 29th of March, 33 deg.; a range of 55.5 deg. for the 3 months.

Snow fell on 5 days; rain on 37 days; solar haloes occurred 5 times; lunar haloes 3 times; lunar coronas 2 times; Aurora Borealis 3 times; a meteor once, and thunder showers 7 times.

WOODEN NAILS.—In these days of millions of iron, copper and zinc nails, tacks and brads; of lightning, self-feeding, and almost automatic

nail machines, it is wonderful to find "wooden" nails coming into use. Yet that such is the fact the "Shoe and Leather Reporter" informs us. Wooden pegs, made by the same machines as shoe pegs, are now largely used for fastening boxes, and manufacturers receive large orders from the West for inch pegs for this purpose. In China, Japan, and Hindostan, pegs of bamboo have been always used in fastening tea chests and other wooden packages. In this age, however, it looks like retrogression to use wood for purposes for which iron seems so much better adapted. As one of the curious freaks of the habit, so inherent in human nature, to return to former customs under the impression that they are novelties, the above is noteworthy, but we do not anticipate a fall in cut nails from this cause.

A Useful Alloy.—A metal composition which may be cast on steel and iron and which will adhere thereto, is much needed, since it is in practice an advantage to unite steel or iron directly with brass by casting; the difficulty of uniting by screws, bolts, or pins, being thus saved. In most cases, however, the inequality of the expansion produced in the two metals by change of temperature prevents their lasting union, and it rarely happens that the superficial union is sufficiently close to be permanent. The following composition closes firmly around iron and steel without any danger of becoming loose. It consists of 3 parts of tin, 39½ parts of copper, and 7½ parts of zinc. Since the last metal is partly converted into vapor at a high temperature, the above proportion may be slightly increased.—*Technologist.*

Iron Slag for Street Pavements.—Some of our Western exchanges, particularly those of St. Louis, are much interested in discussing the practicability of utilizing iron slag for street pavements. Extensive experiments have been made with slag pavements in Brussels, as well as in France, during the past few months, and the results reached have been so favorable, that the attention of practical men in this country have been called to the subject. The slag which it is proposed to utilize in this way has heretofore had no commercial value. It is made in large quantities during the process of smelting iron ores, and has been cast aside as wholly useless, notwithstanding the fact that it contains on the average not less than 10 per cent. of pure iron—sufficient, if properly annealed, to impart indestructible toughness to the block and render the slag of great durability for paving purposes. Whether it can be so used or not depends, to a great extent, upon the cost of preparing it for use in this form. To reheat the slag, mould it into the required shape and bake it, would render it far more costly than the best paving stone. This can be avoided, however, with a little trouble and expense, if the iron manufacturers would have a mould on the "buggy," into which the slag could run when drawn off. When cool enough to be dumped, which it would be in a few minutes, it might be dumped into the ash pile, where, with but little trouble, it could be covered with the hot ashes constantly thrown out, and left to anneal itself by the most inexpensive process imaginable. If, as has been claimed, this process will sufficiently anneal the slag to divest it of that vitreous character which it possesses if cooled too rapidly, a cheap and superior article for street paving might be had wherever iron manufacture was carried on. In moulding the blocks, any desired size or pattern might be obtained, with no other expense than that of preparing the moulds. We can see no reason why this suggestion should not be turned to good account by the iron masters of Western cities, where desirable paving stones can only be be obtained from a considerable distance and at great expense. Properly prepared and laid slag pavement would be both economical and durable, and we can see no reason why it would not be as good, in all respects, as the best stone. Should it come into general use, the manufacture of slag blocks, even at a price low enough to enable them to compete successfully with wood and stone, would prove a source of no little profit to the iron masters, by enabling them to utilize what has not only been worthless, but an incumbrance.—*Iron Age.*

An improved "forge-lamp," for laboratory use, has been designed by Messrs. Delheid and Berge; and although it is essentially a modification of the Bunsen lamp, it is considered to possess important advantages. The forge-lamp consists of a "bougie burner," surmounted by a cylindrical chimney similar to that used with the Bunsen burner, but of rather greater diameter than that generally employed. This chimney descends below the gas outlet, and the air which mixes with it enters all round the jet. When the gaseous mixture is ignited above the chimney a strong draught is produced, which serves the purpose of a blowing apparatus. The air rushes in at the bottom of the chimney very energetically. But the flame from the burner would be very unsteady, and would be liable to be extinguished by a slight gust of air, were it not that this first tube is surrounded by a second of still larger diameter, so that the air for feeding the forge-lamp proper is compelled to pass through the annular space between the two tubes; thus, whilst keeping the apparatus cool, the air is warmed, which contributes to give the forge a great caloric intensity. Under these conditions the gas is very perfectly burned, and the current of air which burns the gas produces the same effect as if it were forced in by blowing. Compared with the Bunsen burners, the main distinguishing features of the forge-lamp are these: The air enters below the gas outlet, and not on a level, or above it, as is usual in Bunsen burners. A larger proportion of air is admitted than in Bunsen burners, as these have their supply of air simply from larger or smaller openings in the air tube, whilst the forge burner receives air from the whole extent of the section of the tube. And there is an additional cylinder which compels the air to cool the sides of the tube, and thus prevents the annoyance of the light running in. As to the results, the forge-lamp is claimed to surpass all apparatus of the kind hitherto proposed, by the extraordinary effect produced considered in relation to the small quantity of gas consumed, and by its extreme simplicity of construction.

Mr. Reid, the engineer of the Great Western of Canada line, has explained to the directors that they must not compare the American railroads of some years ago with the present ones, as they now carry much heavier loads on them, and run trains at a much greater speed, and that the largely increased expenditure upon the main-

tenance and renewals of the railroad have been, in a great measure, forced upon the company by the necessity of bringing up the efficiency of the permanent way to the same high standard as that now attained by the leading trunk lines between New York and Chicago. Those companies, Mr. Reid states, have expended very large sums upon their permanent way, and have so materially improved the condition of their tracks as to admit of their running through trains direct from New York to Chicago during the whole of the winter months at a high speed, and with almost as much regularity as during the summer months. He also states that it is intended to lay down in the track of the Great Western main line 3,000 tons of steel rails during the present half year, which, in addition to the re-rolled iron rails, and the ballasting and drainage works at present in progress, will go far to place the line on a footing of equality at the end of the present year with their rival and connecting lines in the State of New York and the Western States; and that a continuation of the same liberal outlay upon the main line to July, 1871, will, beyond doubt, enable the company to compete on equal terms with the best roadway of their rivals. This is the statement of Mr. Reid, and the company must therefore look forward to a large expenditure for the next six months, or perhaps longer. Steel rails will be laid on the steepest gradients where necessary, and the improved iron rails on the other portion of the track, so as to make the permanent way in all respects as good as that of the London and North-Western. The directors will remove the outside rail, which forms the broad gauge track, so as to leave the main line on the narrow gauge, and make it a most perfect road to meet every demand upon them for carrying traffic.

Wood may be rendered incombustible in a great measure, and preserved underground for a long time by the following process, proposed by Dr. Reinsch. The wood must not be planed, but placed for 24 hours in a solution of silicate of potassa in water, 1 part of the former to 3 of the latter. After removal, the wood is to be dried for several days, again soaked and dried, and then painted over with a mixture of 1 part cement to 4 parts of the liquid first used. Three coats of this paint to be applied. As the paint hardens rapidly, small quantities only should be used at a time. What results have been obtained as to durability by the process of Dr. Reinsch are not stated. Our manufacturers who desire a simpler and speedier process for the preservation of wood will find such in the substance for the preparation of the book-slates and blackboards, and also for the preservation of metals from acids and alkalies. Two coats of this solution, which is composed of some preparation of silicate suspended in a volatile liquid, will render wood fireproof, even under an intense heat, and render it also perfectly impervious to moisture. The paint, or solution, is cheap and efficacious, and also forms a perfect wood filling as a base for varnish.

A Peculiar Boiler Deposit.—This deposit was formed from Croton Water in a boiler, which, by a special arrangement of the steam-pipes, received the condensing waters back again. It had a light brown color, of the specific gravity of water, floating thereon, and had the following composition according to an analysis by Dr. Schweitzer:

Water	1.95	per cent.
Oil (extracted by ether)	20.76	"
Organic and volatile matter	45.23	"
Inorganic residue	26.06	"
The residue consisted of—		
Silicic acid	2.52	"
Stannic acid	1.68	"
Iron and alumina	3.62	"
Carbonate of lime	18.08	"
Magnesia	some.	
Sulphuric acid	none.	

These latter percentages apply to the original mass.—*American Gaslight Journal.*

Chinese Cement.—Among the crude materials sent by Dr. v. Scherzer, from Pekin, was the cement known as schio-liao, which is used in the north of China as paint for wood of all kinds, and by which these substances may be made perfectly water-proof. Dr. Scherzer saw in Pekin a wooden box which had travelled the tedious road via Siberia to St. Petersburg and back, which was found to be perfectly sound and water-proof. Even baskets made of straw became, by the use of this cement, perfectly serviceable in the transportation of oil. Pasteboard treated therewith receives the appearance and strength of wood. Most of the wooden public buildings of China are painted with schioliao, which gives them an unpleasant reddish appearance, but adds to their durability. This cement was tried in the Austrian Department of Agriculture, and by the "Vienna Association of Industry," and in both cases the statements of Dr. Scherzer were found to be strictly accurate. It is prepared in the following manner: To 3 parts of fresh-beaten blood are added 4 parts of slaked lime and a little alum; a thin, pasty mass is produced, which can be used immediately. Objects which are to be made specially water-proof are painted by the Chinese twice, or at the most three times. This cement is not used for such purposes in this country, but it certainly deserves attention, as it is the cheapest really effectual means of rendering wood and other materials perfectly water-proof.—*Technologist.*

Lieutenant-Colonel Shakespear, R. A., is advocating the application of a telescope to the tangent scales of field-guns to meet the case of an enemy's artillery so skilfully posted as to be out of sight to unaided vision. He instances as an example of this the Russian batteries at Balaklava, charged by the Light Brigade, which he himself was reconnoitring through a telescope just before the charge, and which he believes might have been successfully engaged by our batteries had their exact position been earlier observed. Col. Shakespear suggests that a telescope fitted to a gun in the manner which he proposes might also—by a method which he explains—be employed as a "range-finder."

The several ships engaged in carrying the China cable (recently described) have arrived out at their destination, and the submergence of the cable is now supposed to be going on.

A newly discovered quarry of Kansas marble is 10 miles from Baxter Springs and covers 15,000 acres. It is in layers of 6, 8, and 18 in., and 3 to 4 ft. thick; pure white and mottled, and inexhaustible. The latter variety is tinged with pink. It takes a fine polish and finer edge.